Market Diseases

of

GRAPES

AND

OTHER SMALL FRUITS

John M. Harvey and W. T. Pentzer

Agriculture Handbook No. 189

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service

THIS HANDBOOK is one of a group of nine reports on "Market Diseases of Fruits and Vegetables" designed to aid in the recognition and identification of pathological conditions of economic importance affecting fruits and vegetables in the channels of marketing, to facilitate the market inspection of these food products, and to prevent losses from such conditions.

Other publications in this group are:

Miscellaneous Publications

98. Potatoes.
168. Apples, Pears, Quinces.
228. Peaches, Plums, Cherries, and Other Stone Fruits.
292. Crucifers and Cucurbits.
440. Asparagus, Onions, Beans, Peas, Carrots, Celery, and Related Vegetables.
498. Citrus and Other Subtropical Fruits.

Agriculture Handbooks

28. Tomatoes, Peppers, and Eggplants.
155. Beets, Chicory, Endive, Escarole, Globe Artichokes, Lettuce, Rhubarb, Spinach, Swiss Chard, and Sweetpotatoes.

This Handbook is a revision of and supersedes Miscellaneous Publication 340, "Market Diseases of Fruits and Vegetables: Grapes and Other Small Fruits."

Market Diseases

of

GRAPES

AND

OTHER SMALL FRUITS

by John M. Harvey and W. T. Pentzer

Agriculture Handbook No. 189

UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Marketing Service

Market Quality Research Division

November 1960

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C. - Price 30 cents

CONTENTS

Market Diseases

of

GRAPES AND OTHER SMALL FRUIT

By John M. Harvey, *principal plant pathologist,* Horticultural Crops Branch and W. T. Pentzer, *director,* Market Quality Research Division, Agricultural Marketing Service

BLACKBERRIES, DEWBERRIES, AND RASPBERRIES

ANTHRACNOSE

(*Elsinoe veneta* (Burk.) *Jenkins*)

Anthracnose is primarily a disease of the canes and leaves, but may also attack the fruit of blackberries, dewberries, and raspberries. Fruit infected near maturity may be only partially affected by the disease. If individual drupelets are attacked, they fail to develop as fast as unaffected ones, causing the fruit to have a deformed shape. Also the affected drupelets remain green, while unaffected ones ripen to normal color.

Anthracnose is controlled by spraying the growing crop with fungicides and by cultural practices that promote air movement around the plants.

(See *36, 48, 61, 72.*)[1]

BLUE MOLD ROT

(See blue mold rot of grapes p. 10 and pl. 7, *A*).

CLADOSPORIUM ROT

(*Cladosporium herbarum* Fr.)

Raspberries, blackberries, and dewberries sometimes arrive on the market partly covered with an olive to olive-green mold. In raspberries the mold is most abundant on the inside or cup of the berry, but may also occur on the outside. It causes little or no decay of the flesh, either in laboratory tests or in commercial shipments, but renders affected fruit unacceptable for marketing. It is especially

[1] Italic numbers in parentheses refer to items in Literature Cited, page 28.

apt to develop on bruised berries when stored 5 to 7 days at about 40° F.

Control of Cladosporium rot depends primarily on careful handling, expeditious packing and shipment, and refrigeration at temperatures as near 32° F. as possible en route to market.

(See discussion of causal organism under Cladosporium rot of grapes.)

GRAY MOLD ROT

(*Botrytis cinerea* Fr.)

Gray mold causes a soft, watery rot of blackberries, dewberries, and raspberries. The fruit may become covered with a dense, dusty, gray growth of the fungus (pl. 1, *A*) which rapidly spreads from one berry to another under marketing conditions, forming "nests" of decayed fruits.

Gray mold is not as prevalent on brambles in the field as on strawberries, apparently because the fruit of the former are borne singly or in small open clusters and not close to or on the ground. However, the fungus has been found to overwinter in the canes, which provides a source of spores from which the berries may become infected. Rain, fog, or heavy dews favor the development of the disease. Overripe or bruised berries should be culled from the pack as they are more susceptible to infection than sound ones.

Handling methods to reduce gray mold rot are discussed under strawberries and a detailed discussion of the causal organism is found in the section on grape diseases.

(See *17*, *48*, *63*, *76*, *98*, *139*, *156*, *175*, *176*, *177*, *181*.)

RHIZOPUS ROT

(*Rhizopus nigricans* Fr.)

Bramble fruits are similar to strawberries in their susceptibility to Rhizopus rot which is one of the most important market diseases of these fruits. Overripe fruits are particularly subject to the disease since they have little resistance to infection and also are easily bruised, which favors entry of the fungus.

Characteristics of the causal organism and its control are given in the section on Rhizopus rot of strawberries.

(See *13*, *17*, *48*, *98*, *175*.)

BLUEBERRIES

ANTHRACNOSE

(*Gleosporium* sp.)

Blueberries anthracnose is not commonly found on the market except on very susceptible varieties such as Rancocas. In severe cases berries may be completely rotted and show masses of spores in glistening salmon-colored droplets on the fruit surface (Pl. 1, *C*). Tiny black pimples representing fruiting bodies of the fungus are seen on berries held in a dry atmosphere. Infected fruits have blood-red colored flesh.

ALTERNARIA ROT

(*Alternaria* sp.)

Blueberries affected with Alternaria rot remain firm and show a luxuriant gray-white woolly fungus growth from injured cap stem areas when berries are stored in a moist place. Commonly, the fungus causes nesting of the berries in tight clusters scattered throughout the container. Rot may spread through the fruit and produce a blood-red color to the otherwise white-colored flesh.

GRAY MOLD ROT

(*Botrytis cinerea* Fr.)

Decay caused by *Botrytis cinerea* Fr. may develop in blueberries that are held in cold storage before marketing. The severity of decay in storage seems to be associated with weather conditions prevailing during the growing season. The disease is favored by cool, moist weather. Decay caused by infections that occur before harvest may not have advanced far enough to be seen until the fruit has been in storage for several weeks. Varieties differ in their susceptibility to gray mold rot. Jersey and Rubel have been found to be among the best keeping varieties while Cabot is among the poorest. Berries of the Stanley variety have kept better than those of the Weymouth variety in some tests.

Gray mold frequently attacks the fruit at either the calyx or stem end, but may infect almost any area of the berry, causing a soft, watery decay. The grayish-white growth of the fungus rapidly develops on the surface of affected areas (Pl. 1, *B*).

Some control of gray mold may be obtained by growing resistant varieties. The dithiocarbamate fungicides have been very effective in controlling the disease in the field and in preventing post-harvest decay.

(See gray mold rot of grapes p. 13 and strawberries p. 23: also see *7*, *57*, *65*, *104*, *151*, *153*.)

MUMMY BERRY

(*Monoilinia vaccinii-corymbosi* (Reade) Honey)

During certain years the disease known as Mummy Berry may cause serious damage to blueberries. Fruit affected with the disease grow almost to normal size, but become shriveled and are covered with a tan growth of the causal fungus. Diseased fruit is easily shattered from the bush. Consequently, mummy berry is rarely found on the market, although occasionally a diseased berry is not sorted out during the harvesting operation.

The causal fungus produces a hard resting body (sclerotium) within the mummies. These structures enable the fungus to overwinter and produce new spores when the weather is favorable.

Control of the disease has been obtained by field measures such as removing affected shoots and blossoms, raking or disturbing the overwintering mummies to prevent spore formation, and repeated spraying during critical infection periods.

(See *10, 11, 40, 45.*)

PHOMA ROT

(*Phoma vaccinii* Karst.)

Phoma rot has been found on berries from New Jersey and Michigan held for 2 to 3 weeks at high temperatures (75° F.). The disease is evidenced by the appearance of tiny black erumpent fruiting bodies (pycnidia) on the hard and shriveled berry coat. Under high humidity, a creamy white exudate (spores) may be seen oozing from these structures. The organism involved is a facultative parasite and makes its appearance after berries reach their peak of maturity and marketability. The disease is not known to spread in storage. Infection probably originates in the field.

RHIZOPUS ROT

(See rhizopus rot of strawberries p. 26 and pl. 9, *A*).

CRANBERRIES

FREEZING INJURY

Cranberries that have been frozen are tough and rubbery, lack their characteristic high luster, and are often somewhat sticky. Unlike normal healthy berries, they are red throughout rather than only in the epidermis. The cell structure of the berry is not, however, destroyed; the tissues remain intact. Cranberries freeze at about 30° F.

CHILLING INJURY

Except for the absence of stickiness, the symptoms just described are also found in cranberries that have been held at or close to 32° F. for 4 or more weeks, but have not been frozen. This low-temperature or chilling injury can be avoided by holding the fruit at 36° to 40°. Temperatures higher than 40° are undesirable because they favor decay. Low-temperature injury is not common on the market because, under the present system of handling cranberries, not many are held for long periods at temperatures sufficiently low to cause it. With cold storage becoming more popular, this injury may become more prevalent on the market if proper temperatures are not maintained.

SMOTHERING INJURY

The term "smothering injury" is used to refer to a condition like that just described, but which is apparently caused by holding cranberries in containers or in storage space where carbon dioxide accumulates and the oxygen supply is low. The injury is found at times in growers' warehouses, especially if they are overloaded and are not well ventilated. This type of injury is more prevalent when the fruit is held at high temperatures.

Smothering injury is usually found at or near the center of the container, whereas freezing is more likely to occur around the outside. Chilling injury occurs rather generally throughout the container.

OLD AGE (SENESCENCE)

Natural depletion of the food reserves following long storage can also cause a form of physiological breakdown known as old age or senescence. Fruit so affected may be rubbery or it may be somewhat soft and in extreme cases show shrivelling.

FUNGUS ROTS

The rots of cranberries are numerous and are not easily distinguished from each other on causal examination, even by a specialist. The most important rots that develop in storage are end rot (caused by *Godronia cassandrae* Pk.), early rot (*Guignardia vaccinii* Shear), bitter rot (*Glomerella cingulata* (Ston.) Spauld. & Schrenk. var. *vaccinii* Shear), blotch rot *Acanthorhynchus vaccinii* Shear), ripe rot (*Sporonema oxycocci* Shear), fruit storage rot (*Diaporthe vaccinii* Shear), and black rot (*Ceuthospora lunata* Shear).

Rots may be distinguished from the various types of nonparasitic disorders mentioned above since rots generally cause localized spots that become brown or otherwise discolored with some soft or collapsed tissue. Some rotted berries become "water bags." The nonparasitic or physiological disorders generally affect the entire berry causing a uniform red internal discoloration.

Decay is favored by packing the fruit wet, holding it at high storage or transit temperatures, or too long out of storage. The importance of decay is shown by a recent investigation in which losses between the grower and the consumer were about 12 to 25 percent of the total cranberry crop.

Since most fungi affecting cranberries infect the fruit before harvest, rots can be reduced to a considerable extent by spraying with fungicides in the field. Care in picking and handling the fruit to avoid bruising, and cooling it as quickly as possible after harvest and keeping it cool during marketing are also effective control measures. However, cranberries should not be cooled below 36° F. since they are subject to low-temperature injury.

For further details concerning cranberry disorders and their control, consult the following references in Literature Cited: (*12, 18, 19, 50, 78, 79, 131, 133, 134, 135, 136, 147, 150, 155, 159, 162, 170, 171, 178.*)

CURRANTS AND GOOSEBERRIES

GRAY MOLD ROT

(*Botrytis cinerea* Fr.)

The gray mold fungus causes small brown spots (Pl. 1, *D*) to appear which gradually enlarge until one side or the whole gooseberry is affected. This is followed by a soft rot stage and under moist conditions by sporulation of the fungus on the surface of affected fruit.

For further information on the causal fungus, see gray mold rot of grapes p. 13.

(See *36*.)

POWDERY MILDEW

(*Sphaerotheca mors-uvae* (Schw.) Berk & Curt.)

Powdery mildew occurs in practically all parts of the United States where currants and gooseberries are grown, but is most damaging to the latter species. The fungus produces a white, powdery, or mealy growth on affected berries. When the fungus disappears, irregularly shaped russeted areas remain on diseased berries (pl. 1, E, F). Berries subjected to serve attack become deformed and may even crack open and decay.

Control measures are dusting with sulfur, fall pruning, and the removal of weeds, especially beneath the bushes, to allow free circulation of air.

The life cycle of the causal fungus is similar to that causing powdery mildew of grape p. 17.

(See *5, 13, 36, 38, 71, 72*.)

GRAPES

ALMERIA SPOT

The Almeria (Ohanez) variety of grapes sometimes shows a spotting that does not occur on any other variety except possibly Olivette de Vendemain. The spots may occur at any place on the surface of the grape or in any part of the flesh. Those on the surface are faint purple or gray and slightly sunken; those in the flesh are brown and they sometimes underlie a sunken area on the surface. Both kinds resemble drought injury in plums and prunes and can be seen more distinctly if affected fruits are held before a strong light. The spots are frequently associated with a brown discoloration of the vascular bundles (pl. 2, *B*, *C*, *D*).

The cause of the spots is not known. They are not associated with decay and there is no evidence that they increase in number or size in transit or storage. No control methods are known.

ALTERNARIA ROT

(Species of *Alternaria* and *Stemphylium*)

During the storage of Emperor and some other varieties of grapes, decay caused by species of *Alternaria* and *Stemphylium* may develop. Infections by these organisms seem to occur quite early in the harvest season, even in the absence of rainfall. The causal fungi often gain entrance into the berry through the capstem, around which they cause a localized tan to dark brown decayed area in the berry (pl. 3, *C*). Since the fibrous conductive tissue ("brush") that leads into the berry from the capstem is attacked, affected berries are easily shaken from the cluster. Species of *Alternaria* and *Stemphylium* may occasionally be isolated from other parts of the berry where they cause symptoms quite similar to those caused by *Cladosporium*. The color of Alternaria rot is dark brown, rather than black as in Cladosporium rot, the texture is less firm, and the margins of the affected areas are less distinct than Cladosporium rot.

(See *67*, *68*, *140*.)

AMMONIA INJURY

In plants using a direct expansion refrigeration system, grapes are sometimes exposed to ammonia gas that has escaped into the atmosphere of the storage room. Red-colored grapes turn blue and green-colored fruit assumes a slightly bluish cast in the presence of ammonia (pl. 4, *F*). The change in color is caused by the reaction of ammonia with the sap in the cells near the surface of the fruit. When exposed to the gas the sap becomes less acid and the acid-senstive pigments (anthocyanins) in these cells change color.

Most of the gas enters the berries around the capstem attachment, and the adjacent tissues develop the greatest discoloration. Similar discolored areas may form around wounds in the skin. When exposed to ammonia the cap stems turn dark blue or black and portions of the stems become blue.

When an ammonia leak is detected, the gas should be cleared from the room as soon as possible because slight discolorations from the gas disappear when the fruit is removed from the ammonia atmosphere. The fruit will not recover from severe injury resulting from long exposures to the gas. The best way to remove ammonia from the room is with water. In rooms equipped with a spray system for clearing the room of sulfur dioxide this can easily be done.

Another way of minimizing damage from ammonia is to neutralize it with sulfur dioxide. Sulfur dioxide reacts with ammonia to form ammonium bisulfite, a whitish crystalline substance. Approximately 4 pounds of sulfur dioxide are required to neutralize 1 pound of ammonia. No more than a 1-percent concentration of sulfur dioxide should be used, as higher concentrations might cause injury to the fruit. If commodities other than grapes are stored in the room, sulfur dioxide cannot be applied.

(See *46*.)

ANTHRACNOSE

(*Elsinoe ampelina* Shear)

Anthracnose occurs in grapes grown east of the Rocky Mountains, but is not commonly found in the western part of the United States. It also occurs in Europe, South Africa, and Australia. Grape varieties differ in their susceptibility to the disease. Concord, one of the most important American varieties, is quite resistant, as are Beacon, Delaware, and Niagara. Catawba, Campbell Early, Diamond, Ellen Scott, Norton, and Salem are susceptible. Among the vinifera varieties, Thompson Seedless, Malaga, Almeria (Ohanez), Muscat, Grenache, and Flame Tokay are susceptible. Carbernet Sauvignon has shown some resistance to the disease.

Anthracnose spots produced on the fruit are usually brown at first and are surrounded by a narrow zone that may vary from bright red to purple. This stage of the disease is sometimes called bird's-eye rot. Later the affected areas of the berry enlarge, turn gray and become somewhat sunken. The fruit finally dries up and becomes hard and wrinkled, sometimes forming a mummy.

If the grapes are attacked shortly after bloom, parts of the clusters may be girdled, causing them to dry up. Infections that occur during later stages of development may cause affected berries to drop off or to develop abnormal shapes. Diseased fruit is usually culled before reaching the market.

The disease is favored by rainfall and warm wet weather. The causal fungus overwinters in lesions on the stems that become active in the spring and produce spores that infect new growth.

Anthracnose is controlled by spraying in the vineyard, pruning, and using resistant varieties.

(See *5, 36, 44, 54, 55, 72, 83, 121, 132.*)

BITTER ROT

(*Melanconium fuligineum* (Scrib. & Viala) Cav.)

Bitter rot is an important disease of muscadine grapes. The disease also occurs in eastern bunch grapes, but is not as destructive to these as to the muscadines.

The causal fungus may attack the foliage, causing leaf and stem flecks, but the berry rot phase of the disease is most common. Berries are usually not attacked until they begin to mature. Infection frequently occurs at the pedicel and spreads over the entire berry. Bitter rot causes the berries to become soft and to taste bitter. The skin of purple varieties is bleached to a pink color. A crust of black fungus fruiting structures forms over the rotted berry. In advanced stages of the disease, mummies are formed that provide a means by which the fungus overwinters. The formation of mummies helps to distinguish the disease from Macrophoma ripe rot which rarely mummifies the berries and muscadine black rot (Guignardia) which usually does not rot the entire berry. Bitter rot disease may also cause shelling of the berries when the pedicel is attacked.

Bordeaux mixture applied for the control of black rot usually serves to control bitter rot as well. Since late applications may leave unsightly residues on the fruit, copper acetate is sometimes substituted for Bordeaux in sprays applied shortly before harvest.

(See *44, 56, 84, 87, 90, 92, 103, 113, 119, 120, 122.*)

BLACK MEASLES

Black measles is a common disease of grapes in the vineyard, causing losses that range from 4 to 25 percent. The most seriously affected clusters are culled at harvest, but unfortunately a few less seriously affected ones reach market. The disease is characterized by numerous small, irregular, shaped spots, varying in color from bluish or purplish to black, scattered over the surface of the berry (pl. 5, *B*). Berries affected with black measles may occur over the entire cluster or only on one side. In some varities the disease imparts a rather pungent, aromatic flavor to the fruit. The varieties most commonly affected are Malaga, Emperor, Muscat (Alexandria), Burger, Thompson Seedless, Red Malaga (Castiza), and Alicante Buchet. The disease does not develop or spread in storage or transit.

No causal organism for black measles has been established with certainty, but a high correlation exists between the disease and the incidence of wood decay in the vines caused by *Fomes igniarius* (L. ex. Fr.) and a species of *Cephalosporium*. Toxic materials liberated during the decay process are thought to cause an expression of disease symptoms in the fruit and vine.

Control of the disease in California has been obtained by spraying or swabbing the pruning wounds with sodium arsenite solution while the vines are dormant. At least 4 weeks should elapse between pruning and treatment to avoid injury to the vines. For 100 gallons of spray solution, 3 quarts of sodium arsenite containing an equivalent of 4 pounds arsenic trioxide per gallon should be used.

(See *8, 23, 28, 37, 75, 82, 101.*)

BLACK ROT

(*Guignardia bidwellii* (Ell.) Viala & Ravaz)

Black rot is one of the most serious diseases of grapes in the eastern United States and in Europe. The disease is not found in the grape-growing areas of California. In the regions where the disease is found, it does more damage than all other grape diseases combined. Both European and American grape varieties are subject to the disease, but a few American varieties show some resistance. Black rot is essentially a field disease and affected fruit is usually removed and discarded before reaching the market. Affected grapes that do reach the market are wrinkled, dried up mummies. Black rot does not develop or spread in transit (pl. 6, *D*, *E*, *F*, *G*).

Muscadine grapes are attacked by a different form of the fungus, *Guignardia bidwellii* f. *muscadinii* Luttrell, and are not affected by the form of the fungus found on other grape species. Muscadine varieties differ in their susceptibility to the disease. The disease is favored by warm, wet weather.

Control is by spraying in the vineyard and pruning out diseased branches.

(See *14*, *15*, *30*, *31*, *44*, *62*, *72*, *85*, *88*, *91*, *103*, *117*, *121*, *123*, *163*, *164*, *180*.)

BLUE MOLD ROT

(*Penicillium* sp.)

Blue mold rot sometimes affects grapes before harvest and may damage them quite severely in transit and storage. It is characterized by a scanty growth of mold which is white at first and turns bluish-green later. At harvest the mold is usually associated with wounds or cracks in the skin, but in storage or transit it may form a rather heavy growth on the stems and cause berry decay (pl. 7, *A*). The decayed tissues are very soft and watery and have a moldy smell and taste.

Vinifera grapes that are fumigated with sulfur dioxide in storage do not usually have the disease. Blue mold rot will develop slowly at 32° F., however, if the fruit is not fumigated.

(See *29*, *140*.)

BRUISING

Bruising injury occurs on grapes that are in contact with the sides, bottom, or lid of the container during storage or transit. The affected areas are flattened and vary in size according to the severity of rubbing or pressure to which the berries have been subjected (pl. 4, *E*). The affected areas sometimes show no discoloration, but may turn brown on light-skinned fruit and dark brown or black on dark-skinned fruit.

Grapes that are fumigated with sulfur dioxide become bleached in the bruised areas. Severe bruising predisposes the fruit to decay under favorable temperature conditions.

CLADOSPORIUM ROT

(*Cladosporium herbarum* Fr.)

Occurrence and Symptoms

Cladosporium rot is an important cause of spoilage in grapes held in cold storage, particularly the Emperor and Flame Tokay varieties. It is one of the chief causes of spoilage in stored Emperor grapes that are harvested early in the season, while gray mold rot is more prevalent in grapes harvested late in the season. Cladosporium causes a black, firm decay that is usually localized on one side or at the blossom end of the berry. The decay is not definitely sunken, but the grape is flat or wrinkled on the affected side. The decay is shallow and usually does not extend to the seeds. The affected tissue is firmly attached to the skin and can be easily removed with it. In storage the fungus is usually not present on the surface of the affected berries (pl. 3, *B*), but when the fruit is removed from storage and kept at room temperature, a sparse surface growth of gray-green or olive-green fungus may be produced (pl. 7, *B*).

Causal Factors

The causal fungus is widespread in nature and grows on a wide variety of dead organic materials. Infection of uninjured grapes occurs under favorable conditions, but the fungus is more often associated with wounding. The small growth cracks at the blossom end of the berry, which frequently occur in Flame Tokay grapes, are often infected with Cladosporium. If such berries are not culled at harvest, further spoilage of the affected berries occurs during storage and decay may spread by contact from diseased to healthy berries.

Growth of the causal fungus has been recorded at temperatures as low as 18° F., well below the temperature at which grapes are stored. The fungus grows best at 75° and growth ceases at temperatures above 93.5°. Infection of grapes has been observed to occur at temperatures between 39° and 86°, the optimum temperatures for infection being between 70° and 75°, depending upon the variety.

Control Measures

Fumigation of vinifera grapes with sulfur dioxide reduces postharvest infections of grapes by Cladosporium and other fungi and reduces spread of decay from affected to sound berries in storage and transit. (See details under gray mold rot). Prompt cooling and storage of 31°–32° F. will delay development of this disease. Applications of fungicides in the vineyard have not resulted in significant control of Cladorsporium rot in stored grapes.

(See *20*, *42*, *51*, *53*, *67*, *68*, *69*, *140*.)

CRACKING

Grapes of the Flame Tokay, Mission, Petite Syrah, Ribier (Alphonse Lavalee), Red Malaga (Castiza), and Thompson Seedless varieties sometimes show cracking at the blossom end or on the side. The cracks are rarely more than ¼-inch long and ⅛-inch deep. In time the edges of the broken skin become dry and curl inward. Cracked berries frequently become infected with various decay organisms, especially in storage. That caused by gray mold is the most serious, develops the most rapidly, and may not only destroy the grape in which infection originally occurred, but may spread to others around it. Cracked fruit may also be infected by an olive-green mold (*Cladosporium herbarum*) which appears in dry, hard pockets ⅛- to ¼-inch deep. Cracking associated with rain damage may be particularly prevalent in Muscat (Alexandria) and Thompson Seedless. This cracking is at the side or at the stem end, the latter taking the form of partial or complete circles around the capstem.

Cracking of eastern grapes (American varieties) seems to be associated with wet weather late in the summer, and there is some evidence that is can be reduced by late cultivation. Rainfall late in the harvest season causes cracking in the vinifera varieties, Emperor, Ribier, and Almeria (Ohanez). Thompson Seedless sometimes crack when placed in storage at high humidity. It is usually harvested before the rainy season in California, so rarely suffers from rain damage. (See *94*)

DEAD-ARM ROT

(*Cryptosporella viticola* Shear)

Dead-arm is primarily a disease of the leaves and shoots of the vine, but may also affect the grape cluster. Usually affected fruit is culled before reaching market, but occasionally the disease is seen in marketed table grapes. In California the Flame Tokay variety may be quite seriously affected with dead-arm. The disease is widespread on many varieties of grapes grown in the Eastern United States.

Decay of the berries resembles that caused by the black rot organism, but is slightly more bluish-gray in color and the pustules are less numerous, larger and more scattered than in black rot. The black fruiting bodies of the fungus are sometimes arranged in concentric circles over the decayed portions of the berries. Affected berries eventually form mummies, but these are not so shrivelled or hard as in black rot.

Infections by the causal fungus is favored by rainy, foggy, or misty weather. Control consists of pruning to remove affected shoots and the application of dormant sprays.

(See *6*, *7*, *8*, *56*, *66*, *72*, *73*, *74*, *101*.)

DOWNY MILDEW

(*Plasmopara viticola* (Berk. & Curt.) Berl. & De Toni)

Downy mildew does not occur on cultivated grape varieties grown in California, but causes extensive damage in other grape growing areas. The disease is rarly seen on fruit on the market. Symptoms on the fruit are brown or brownish-purple patches that occur at separate points. Later the skin becomes withered and eventually the whole berry becomes shrunken and dark brown.

Downy mildew, is controlled by a carefully planned spray program in the vineyard.

(See *44*, *71*, *72*, *137*.)

FREEZING INJURY

Native grapes of the eastern United States that are injured by freezing become shriveled, because of rapid evaporation from the skin, and usually show a milky, opaque condition of the pulp. Normal uninjured pulp is greenish and semitransparent. Severely frozen grapes become so watery and disintegrated that breaking the skin allows all the material inside, including the thin, pulpy layer on the inner side of the skin, to come out, leaving only a shell. Blue varieties undergo no color change in the skin, but red or green varieties may show a slight browning.

Vinifera varieties that are injured by freezing have a dull appearance and are soft and flabby. After severe freezing they turn brown and become wet and sticky (pl. 4, *A*). The stems and capstems are often injured by temperatures that apparently have no effect on the berries. The frozen stems are at first limp and pliable, with a water-soaked or dark-green appearance, but they soon dry and become dark colored. However, if grapes are frozen after having been fumigated with sulfur dioxide in storage, the stems may not turn dark, but retain their former green or straw-yellow color. When berries, injured by freezing, are pulled off the capstem, the brush (the small bundle of fibers that extends from the capstem into the berry) is usually found to be shorter than normal and somewhat browned.

Freezing points of berries vary with the variety and maturity of the grapes. Average freezing points of Emperor, Ribier, Tokay, and Thompson Seedless are 27.4°, 27.3°, 26.5°, and 27.2°F, respectively. The freezing points of the stems are somewhat higher than this, however.

(See *169*.)

GRAY MOLD ROT

(*Botrytis cinerea* Fr.)

Occurrence and Importance

Gray mold rot occurs in all the principal grape growing areas of the world. The fungus causing this disease is widespread in nature and causes decay in many kinds of fruit, vegetables, and ornamentals. This disease is one of the principal causes of spoilage in storage grapes because the causal organism is capable of growth at low temperatures. The chief storage varieties in California are Emperor, Ribier, Almeria (Ohanez), Calmeria, and Flame Tokay. Gray mold is particularly prevalent in these varieties when they are harvested late in the season or after they have been exposed to high moisture conditions in the vineyard.

Symptoms

Several common names are used to describe the various stages of gray mold rot. The early stage of the disease is called "slip skin" since, after infection, the tissue just beneath the surface of the berry is attacked first, loosening the skin from the underlying flesh. A slight pressure applied to the berry causes the skin to break loose and separate from the firmer underlying tissue, hence the name, slip skin. There may be a slight browning of the affected area of the berry, but at this stage, the decay is not readily discernible by appearance alone (pl. 3, *A* and pl. 6, *B*, *C*).

Later the causal fungus grows through the entire inner flesh of the berry, resulting in a soft, watery mass of decayed tissue enclosed in a still somewhat intact, but browned skin. Under moist conditions the fungus sporulates on the surface of the berry, producing the typical, powdery gray mold stage of the disease (pl. 6, *A*). Diseased berries gradually lose moisture, shrivel, become a darker brown color and form the mummy stage of decay. In storage the fungus may spread by contact from diseased berries to adjoining ones, in which case the "nest rot" stage of the disease is formed. When nest rot occurs there is usually a rather well developed growth of grayish-white mold over the surface of the affected fruit.

Casual Factors

The causal fungus, *Botrytis cinerea*, is able to grow on many kinds of dead organic materials in the vineyard. When the weather is cool and moist, the fungus produces spores which are carried by air currents to the surface of grape berries. These same cool, moist weather conditions allow the spores to germinate and infect the grapes. In California the early part of the harvest season is usually dry, but rains, fog, heavy morning dew, or periods of high humidity often occur late in the harvest season. The time required for infection varies with the temperature, the humidity, the presence or absence of free moisture on the berry surface, and with the particular variety. The optimum temperature for spore germination is about 68° F. Spores lose their viability at temperatures above 111°. Susceptibility to infection increases with the maturity of the grapes. Under favorable conditions infection may occur directly through the uninjured skin of the berry. However, the fungus can also infect grapes through wounds or cracks in the skin under conditions when direct infection would not be possible. In the vineyard certain bunches may be very compact, causing the berries on the inside of the bunch to split during growth and leak juice. These berries become infected with gray mold and other fungi, causing a condition known as bunch rot. Such diseased bunches are usually discarded before the fruit reaches market, but occasionally a bunch that is not severely affected escapes detection and is marketed. One or two field infected berries may lead to the development of nest rot during transit or storage.

When grapes are fumigated with sulfur dioxide, spores on the surface of the berries are killed, but that part of the fungus which has already penetrated the berries is not. Such infections may not have developed far enough to be detected at harvest, but develop further during storage or transit. These infections which occur in the field are the primary cause of post-harvest spoilage.

Control Measures

Spoilage from gray mold rot in grapes can be reduced by preventing field infections, by careful handling, precooling and refrigeration, by post-harvest fumigations, and by judicious marketing of storage lots according to their decay potential.

Vineyard applications of fungicides to prevent field infections of vinifera grapes have been effective in reducing decay in storage. In California a dust containing 10 percent captan may be applied to varieties that mature late in the season and are likely to be exposed to high moisture conditions. The first application should be made while the clusters are still loose (July 1 to 15) and additional applications should be made at 3- to 4-week intervals. The dust should be directed toward the clusters and applied to every row at the rate of about 20 pounds per acre. Applications of captan may be combined with the regular sulfur dustings for powdery mildew control.

Pruning, trellising, and thinning methods that lower the humidity around the clusters and prevent the formation of compact clusters are helpful in reducing decay in storage since they lower the percentage of berries infected in the vineyard. Some workers have found that excess nitrogen fertilization favors gray mold rot. There is evidence that control of insects that cause wounding of the berries indirectly reduces gray mold rot.

Grapes for transit should be rapidly cooled to at least 40° F. and those for storage should be cooled to 31° to 32°. However, since gray mold is capable of growing slowly even at these low storage temperatures, further control measures are necessary.

American, or eastern, varieties of grapes cannot be fumigated with sulfur dioxide because of their susceptibility to injury, but vinifera grapes should be fumigated, either in the refrigetator car or in the cold storage room. The usual method of application is to release sulfur dioxide from cylinders of liquified gas into the car or storage room where it is allowed to mix with air. A supplemental fan should be installed in the brace of the load of each refrigerator car to insure uniform distribution of the gas. Without such a fan the fruit on the periphery of the load is over-exposed to fumigant (see section on sulfur dioxide injury) and that within the load does not receive enough gas to control decay. A one-percent concentration of gas is used for the first fumigation and if the grapes are stored, additional fumigations with lower concentrations of gas (one-fourth percent) are made at weekly or 10-day intervals. When fumigation is done in cars, more gas is required if the bunkers contain ice than if they do not, as sulfur dioxide is readily dissolved in the water on the surface of the ice.

In addition to the method of fumigation just described there is another that involves the use of sodium bisulfite, a compound that releases sulfur dioxide slowly when brought in contact with moist air. Five grams of this chemical, sprinkled in the paper pad used at the bottom of display lugs or mixed with the sawdust sometimes used as a packing medium, has generally given satisfactory protection against mold and decay during short periods.

Losses from gray mold rot in storage can be further reduced if individual lots are selectively marketed according to their decay potential. A rating of lots for storability can be based on a knowledge of the storage history of fruit harvested in past years from various vineyards, on the general appearance of the fruit at harvest, on the weather to which the fruit had been exposed before harvest, on periodic inspections made during the storage period, or on a laboratory forecast of the potential storage decay present in specific lots of fruit at harvest. The forecast is based on the measurement of incipient field infections present at harvest, using an incubation technique. The decay that develops in samples taken at harvest and incubated for 10 days is indicative of the amount of decay that will develop over a much longer period in cold storage. Lots in which a high decay potential is indicated can be marketed early before decay has time to develop and lots in which a low decay potential is indicated can be safely stored to take advantage of favorable markets late in the storage season.

(See *21, 25, 26, 35, 49, 53, 55, 67, 68, 69, 97, 99, 100, 102, 105, 106, 107, 108, 109, 114, 115, 116, 118, 128, 129, 130, 140, 141, 142, 143, 144, 166, 167, 168, 172.*)

HAIL INJURY

Grapes that have been torn by hail are of course easily recognized if examined a day or two after the injury occurred. There is, however, another form of the injury that may at times be confused with internal browning (p. 16). This injury occurs when grapes are hit by hailstones, but in such a way that the skin is not broken. It is characterized by a browning of the flesh on one side of the fruit instead of in a zone completely surrounding the seeds, as in internal browning. As seen from the outside, it appears merely as a darker spot on the side of the berry. No study has been made of the effect of such injured places on quality changes during marketing, but it is probable that the skin over them is weakened and the fruit is more susceptible to attack by decay organisms (pl. 2, *A*).

INTERNAL BROWNING

Thompson Seedless grapes that are stored for 2 to 3 months frequently develop an internal discoloration that detracts from their appearance and affects their marketability. The flesh of the light-colored berries begins to turn a gray or brown color, frequently toward the blossom end. Although deep within the flesh, the discoloration is visible from the surface, giving the fruit a gray, dull, lifeless appearance. The disorder may appear in only a few clusters in a box or in a few scattered berries on each cluster. The incidence and severity of internal browning increases in proportion to the length of storage. When the fruit is held at room temperature, following a long storage period, internal browning may double in severity and percentage of berries affected within a day.

Grapes of the Malaga variety show a similar disorder, some berries in the cluster appearing slightly darker than the others. When cut, the flesh surrounding the seeds and extending to within about $\frac{1}{16}$-inch of the skin is found to have a brownish discoloration.

Internal browning is not due to decay and is not followed by molding. In Thompson Seedless, it is apparently a symptom of physiologic aging, since there appears to be a correlation with length of storage and maturity; fruit bordering overripeness at harvest is most susceptible to browning in storage. Under experimental conditions, incidence of this defect is greater when grapes receive relatively heavy applications of sulfur dioxide in storage than when they receive a minimum of gas.

Reduction of losses from internal browning lies in the careful selection of fruit of optimum maturity and quality for long-term storage and in judicious marketing of the fruit before the disorder appears. Frequent inspection of storage lots should be made to detect the first appearance of browning.

POWDERY MILDEW

(*Uncinula necator* (Schw.) Burr.)

Occurrence and Importance

Powdery mildew occurs in practically all parts of the United States where grapes are grown, but it appears on the market almost exclusively on grapes from California. European or vinifera varieties are much more susceptible than those native to the United States. Powdery mildew is most frequently observed on Flame Tokay, Carignane, Muscat (Alexandria), Olivette Blanche, Petite Syrah, and Zante Currant. It is less often found on Alicante Bouschet and Mataro. However, all vinifera varieties may be injured severely if weather conditions are favorable for the growth of the fungus and no effort is made to control the disease.

Claims have been made at various times that mildew leads to decay in transit. It is known to occur on the stems of the bunches, and while sulfuring in the vineyard (in California) and careful culling at the packing house do much to keep mildew out of the packed fruit, there is always a possibility that in a mildew season a small percentage of bunches carrying mildew on the stems may go into the pack. There is no evidence that the mildew develops further after the fruit leaves the vineyard, or that it predisposes the fruit to decay except possibly by weakening the skin so that cracks are more common and decay fungi find easier entrance. Mildew russeting as seen on the market is usually mild, and such cracks as can be found are very small and have healed over.

Symptoms

On the berries powdery mildew causes a light-brown, lacy russeting (pl. 8, *D*) which is easily distinguishable from the solid brown patches produced by sunburn and from the small black or purplish-brown spots characteristic of black measles. Affected berries may be somewhat dwarfed, but no rot is associated with the disease. On the stems of the bunches, mildew spots are gray at first, then turn brown. From the central brown patch on the stems, fine, brown, weblike lines extend in a more or less radiating pattern, eventually forming spots an inch long or even longer, since several infections may run together.

Causal Factors

The powdery mildew fungus is favored by moderate temperatures (70° to 86° F.) such as those that occur in the coastal valleys of California during the growing season. The high temperatures common to the interior valleys of California tend to inhibit development of powdery mildew, but are not generally high enough for a long enough period to prevent the disease. There is a general belief that the disease is favored by high moisture conditions. However, some workers have found that moisture has a very slight effect on the development of powdery mildew, the fungus being able to cause infection at both low and high atmospheric humidity. Temperature is the primary factor affecting infection.

Control Measures

On vinifera varieties, the disease can usually be controlled by one to six or more applications of sulfur dust, the number and time depending on locality, weather, variety, and the exposure of the vine. Where mildew is severe the first application of sulfur is usually made when the shoots are 6 inches long. Subsequent applications are made when the shoots are 12 to 15 inches long and at 14-day intervals thereafter. Five to ten pounds per acre are applied, the amount being varied according to local weather conditions. Overapplication should be avoided in hot weather to avoid sulfur burn.

Spraying with Bordeaux mixture has been found to give satisfactory control of the disease on American grape varieties in New York. Sulfur dust causes considerable injury to these varieties.

(See *8, 22, 24, 36, 41, 44, 64, 80, 179.*)

RAISINING

Raisining may occur in vinifera grapes in California and other parts of the world when the crop is subjected to extremely hot weather during the harvest season or when there is too long a delay in removing the crop from the vine. Raisined berries are usually removed from the cluster during packing, and consequently advanced stages of raisining are rarely seen on the market.

Four types of berries can usually be recognized in bunches where raisining occurs: (1) Plump, fresh berries that have normal color; (2) berries that are still plump, but have begun to turn brown; (3) berries that are brown all over, have lost moisture, and are becoming flabby and soft; and (4) those in which drying has progressed far enough to reach the color, taste, and physical condition of raisins (pl. 8, *A*). White or green varieties darken as they dry, and when found in the soft, flabby condition are sometimes thought to be decayed. A correct diagnosis is easily made by tasting a few affected berries.

Cultural practices which provide a good cover of foliage over the fruit to protect it from the direct rays of the sun help to prevent raisining.

RHIZOPUS ROT

(*Rhizopus nigricans* Fr.)

Rhizopus rot may develop in grapes at the market level when the fruit is not adequately refrigerated. It is not an important cause of decay in the field, under California conditions, but sometimes causes field rot in other parts of the country. The disease never develops in storage grapes, because the causal fungus is incapable of growth at the temperatures at which grapes are stored, 31° to 32° F.

Rhizopus causes extremely soft, watery decayed areas to develop which rapidly spread over individual grape berries, from which the mold moves to adjacent ones. Once started in a box of grapes, the mold will soon spoil all the fruit it can reach, if temperatures are favorable. Affected fruit is covered with a luxuriant growth of coarse mold, spotted with the stalked, black fruiting bodies of the fungus.

Infection is usually through wounds or bruises that may result from rough handling or through cracks caused by rain or other factors. Sound berries are infected readily when in contact with diseased ones.

Control of the mold lies in rapid precooling, refrigeration below 40° F., and careful handling to prevent tearing the capstems from the berries or otherwise injuring the fruit.

See section on Rhizopus rot of strawberries for details on the causal organism and its control.

(See *140*.)

RING MILDEW

Malaga and Muscat (Alexandria) grapes grown in California occasionally show a brown spotting that is known as ring mildew or fingerprint mildew. No evidence has been obtained that the spotting is caused by the grape powdery mildew, or indeed by any other organism; yet it keeps its name and has the appearance of being more than a mere russet brought about by any mechanical or chemical agent.

The spotting is well described by its various names. It is entirely superficial and the spots are more or less in concentric circles (pl. 2, *E* & *F*). The spotting may occur anywhere on the berry, but is usually found at or near the blossom end. Bunches with more than half a dozen of the spotted berries are rare, and there are vineyards in which the blemish does not seem to occur at all.

RIPE ROT

(*Botryosphaeria ribis* Gross. & Dug.)

Ripe rot has been observed in muscadine grapes (*Vitus rotundifolia* Michx.) where it is second in importance to bitter rot. It develops about the time the berries reach full size and ripen. Many of the infected berries fall off before they are picked. Thomas, Lucida, Howard, and Dulcet are susceptible varieties while Hunt, Creek, Scuppernong, Irene, and Yuga are highly resistant.

The disease first appears as small, brown, sunken spots with light tan centers on the surface of berries. The fruiting bodies of the imperfect stage (Dothiorella) of the causal organism may be formed in this spot. Later a soft brown rot involves the whole berry which then may dry out leaving a hollow shell covered with the fruiting bodies of the fungus.

The disease is usually not serious enough to warrant control measures. However, those employed for bitter rot (p. 8) may also be applied for control of ripe rot.

(See *84*, *89*, *92*.)

SCARRING

Several different kinds of marks or spots occur on grapes and may be grouped under the term "scarring." Among them are the following:

1. Cane or leaf rubs are brown to black in color, somewhat elongated in shape, and usually have a smooth surface (pl. 8, *E*).

2. Spots caused by hail injury (see p. 16) when the fruit was young are tan-colored, have a roughened surface, and are generally depressed below the uninjured skin around them.

3. Thrips injury causes russeted areas on the berries and sometimes involves the entire surface.

4. Small, circular, smooth, brown spots or flecking sometimes occur on the skin of Thompson Seedless and Malaga. The cause of these is unknown.

5. The spotting known as black measles is described on page 9.

Scarring of any kind detracts from the appearance of the fruit, but, so far as known, none of the types named here predispose the fruit to decay.

SHOT BERRY

Shot berry is seen most often in Muscat (Alexandria), Ribier, Cardinal, and in some years in Emperor and Malaga grapes. This defect is characterized by small, poorly developed berries that are scattered among the normal-sized berries in the bunch (pl. 8, *C*). In varieties that normally produce seeds these small berries are usually seedless.

The condition is frequently seen in fruit as it comes from the field but many of the affected berries are trimmed out before packing. It is not associated with decay of any kind, either of the stems or of the berries.

Shot berry is apparently a result of poor pollination, through the factors contributing to the defect are poorly understood.

SULFUR INJURY

Dusting grapes with sulfur to control powdery mildew sometimes causes severe injury to the skin. The injury is usually on the side of the berry exposed to the sun and appears as smooth brown areas, varying in size from about 1/16- to more than 1/2-inch across. The spots are superficial and do not seem to lead to decay. Most packing-house managers try to keep them out of the table pack, because of their effect on the appearance and consequently on the market value of the fruit. They are of no significance in juice stock.

To prevent injury sulfur applications should be withheld when the temperature is above 110° F. Field tests have shown that sulfur causes injury to both leaves and fruit above that temperature. Uniform distribution of sulfur is also recommended to prevent injury.

SULFUR DIOXIDE INJURY

In California, grapes are commonly fumigated with sulfur dioxide to prevent the development of decay. If too much gas is applied, or if fumigation is continued too long, grapes may be injured enough to seriously impair their market value. If grapes are weak, immature, or very warm, they absorb the gas more readily than if they are firm, mature, or cold, and are, therefore, more likely to be injured by fumigation. Some varieties take up the gas faster than others and consequently are more easily injured. Fairly resistant varieties are Ribier and Alicante Bouschet; susceptible ones are Red Malaga (Castiza), Flame Tokay, and Emperor.

Injury may occur in two fairly distinct forms: (1) A bleaching or decolorization of the skin of the fruit, usually most pronounced at or near the stem end, around cracks in the skin, or sometimes over a considerable surface of the berry (pl. 4, *C*); and (2) a pitting or bleaching of scattered small areas over the surface of affected berries as in the Flame Tokay variety which is particularly susceptible to this type of injury (pl. 4, *B*).

If the injury and bleaching occur only in a narrow zone at the stem end, that part of the skin and the underlying flesh may eventually dry out and collapse, thus forming a small depression or cup (pl. 4, *D*), which at first might be mistaken for the beginning of Alternaria rot. However, the skin over such a depression is bleached, not brown, and there is no odor or taste of decay.

In mild injury the coloring matter of the skin is not destroyed, or so little is destroyed that there is no perceptible color change. In severe injury colored varieties may be bleached and white ones assume a grayish cast. The normal color does not return even though the fruit is removed from the car or other storage space and exposed for several days to the air. At such warm temperatures, injured grapes usually develop a brown, unattractive color, probably resulting from oxidation of injured tissues. Badly injured grapes usually have a distinctly disagreeable, astringent flavor.

(See *3, 9, 52, 81, 93, 105, 106, 107, 108, 118, 128, 129, 167, 173, 174*.)

SUN INJURY

During periods of extremely high temperature, that may occur in the desert and central valleys of California during the ripening season, grapes suffer various degrees of injury from the heat and the direct rays of the sun. In one of its mildest forms, sun injury is expressed as a slight roughening or dulling of the grape skin, usually on the side of the bunch most exposed to the direct rays of the sun. This symptom is sometimes called "buckskin" and is more common in Flame Tokay than in other varieties. Exposed Thompson Seedless fruit frequently turns an amber color. Sun injury in Malaga, and sometimes in Muscat (Alexandria), Almeria (Ohanez), Emperor, and Olivette de Vendemain, occurs as tan to dark-brown spots that vary in size from ¼ inch in diameter to half the surface of the berry (pl. 5, *A*). Under a hand lens these areas show a delicate streaking lengthwise of the berry, in contrast to the lacy appearance of mildew spots. They are largest and darkest on bunches at the top of the vine or on the southwest side where exposure to the sun is greatest.

Sun injury in its severest form appears as a definite sunburn of the berries which may result in the killing and drying up of part or all of the fruit in bunches at the top of the vine or in places fully exposed to the sun (pl. 8, *B*). Unexposed fruit may become wilted or softened, and sometimes collapsed permanently. In certain Malaga vineyards known to have suffered from high temperatures, cavities have been found in the pulp of the collapsed berries.

Sun injury usually does not lead to decay during transit and marketing unless severe enough to cause dead tissue on the surface of berries or dead berries in the clusters. Fungi, such as *Cladosporium* and *Alternaria* species, grow readily on dead tissue and may thus gain entrance into the fruit. The presence of injured berries lowers the quality of the pack and fruit with slight injury may mistakenly be classed as overmature, lowering its marketability.

Cultural practices in the vineyard that provide a good canopy of foliage over the clusters reduce the danger of sun injury. Protecting the fruit is more difficult in vines that are "head pruned" than in those that are trained on a trellis. Affected fruit should, of course, be carefully trimmed from the clusters before packing.

WATER BERRY

Grapes affected with water berry are soft and watery and so low in sugar content that the hydrometer test on bunches showing a large proportion of them may run 5 to 10 percent below the usual figure for the variety. They are easily cracked or crushed by the handling incident to picking and packing, and therefore favor the development of decay during marketing. Water berries may occur anywhere in the bunch, but are found most frequently toward the lower end or at the tips of the laterals. The varieties most often affected are Malaga, Thompson Seedless, Emperor, and Flame Tokay.

The Carignane variety sometimes shows a condition resembling water berry. Affected berries are soft and flabby and when pulled from the bunch and squeezed, their contents are found to be in an almost liquid condition that suggests decay. No decay organisms are associated with the disorder, however.

The condition known as red berry in the Zinfandel, Cornichon, Mission, and other black varieties shows all the characteristics described for water berry except that affected grapes have a dull-red color instead of the black or blue-black that is normal for the variety. Red berry is easily recognizable in the vineyard.

What causes grapes to become watery and fail to develop into firm, crisp berries is not known. Growers have observed, however, that firmer, better storage grapes are produced if the vines are not too heavily loaded. In growing Thompson Seedless grapes, firmer, larger, and more attractive fruit can be obtained by thinning the bunches on the vine and the berries on the bunch. Removing the tips of the bunches where most water berry occurs, and girdling the canes upon which the fruit is borne is helpful in preventing this defect.

STRAWBERRIES

ANTHRACNOSE

(*Gloeosporium* sp.)

Occurrence and Importance

This disease is presently of minor importance having been noted only in small amounts on truck shipments of ripe fruit from Louisiana.

Symptoms

The fungus produces brown to dark brown, slightly sunken lesions of varying sizes anywhere on the surface of the berry (pl. 9, *C*). The rot is shallow, somewhat firm, and under humid conditions salmon-colored spore masses may be produced on the surface.

Causal Factors

This decay is favored by warm, wet weather conditions and is probably spread to the berries from previously infected parts of the strawberry plant.

Control

Specific control measures have not been established but it is thought that routine fungicidal measures maintained by growers for leaf spotting diseases will assist in checking the ripe fruit rot.

GRAY MOLD ROT

(*Botrytis cinerea* Fr.)

Occurrence and Symptoms

Gray mold rot is one of the most serious diseases of strawberries. It is most common in the cooler producing regions, where it sometimes causes a loss of 10 percent or more of the crop in the field. The disease is caused by the same species of *Botrytis* that attacks grapes. Gray mold rot is especially favored by wet weather and is worse in places where heavy leaf cover provides conditions that are particularly favorable for the growth of the fungus on flowers, flower stalks, fruitstalks, and various kinds of debris on the soil as well as on the fruit.

Gray mold rot of strawberries is firm and fairly dry superficially. There is no marked collapse of the tissues and little or no leakage of juice. Affected areas on berries are brown at first, but as the fungus spreads over the entire berry, powdery, gray fructifications are produced (pl. 10, *A*, *F*, *G*).

Causal Factors

The causal organism and its relation to temperature and moisture are discussed in detail under gray mold rot of grapes (p. 13).

Control Measures

Control of the rot in the field is difficult if conditions there favor its development, but recent work with certain fungicides (captan and ferbam) show that decay can be greatly reduced both in the field and after harvest by field applications of fungicides. Control in transit and during marketing depends on careful handling of the fruit to avoid bruises and skin breaks, careful culling wherever feasible to remove decaying fruits, and a temperature below 40° F. Culling is most effective when done in the field, because this practice avoids much of the bruising likely to occur if culling is done in the packing shed. During long transit periods, as occur in strawberries shipped from California to eastern markets, temperatures between 32° to 35° are desirable. Refrigeration is sometimes supplemented with carbon dioxide (dry ice) to modify the atmosphere in the refrigerator car. Atmospheres high in carbon dioxide tend to slow the respiration rate of the fruit, thus extending its market life, and also reduce the activity of decay-causing organisms.

Development of gray mold rot and other rots on the market can best be prevented by moving the fruit into consumption as quickly as possible and, when holding the fruit is necessary, storing it at 31° to 32° F. Treating the berry boxes (hallocks) to prevent mold growth in fruit destined for processing has been quite effective in reducing decay.

(See *4*, *16*, *32*, *33*, *34*, *39*, *43*, *47*, *59*, *60*, *70*, *77*, *86*, *95*, *96*, *110*, *111*, *112*, *125*, *126*, *138*, *139*, *146*, *148*, *149*, *152*, *154*, *158*, *161*, *165*, *175*, *176*, *177*.)

LEATHER ROT

(*Phytophthora cactorum* (Leb. & Cohn) Schrote.)

Occurrence and Symptoms

Leather rot is a fungus disease of strawberries that has been found in the field in Mississippi, Louisiana, Arkansas, Tennessee, Virginia, Maryland, Missouri, Illinois, and Kentucky and on the market in carlot shipments of strawberries from these States.

Leather rot is characterized by a rather slight softening of affected tissues, by both external and internal discoloration, and by a marked bitter taste. The tissues, become tough and leathery, so that the softening never even approximates the mushy, leaky condition produced by *Rhizopus*, nor the soft-spot condition produced by certain other molds. The discoloration, particularly on the outside, varies considerably. Affected areas of immature fruit are yellow to light brown at the center and shade from this through darker brown to purple to the natural red of the berry; ripe, fully colored fruits sometimes show no color change at all except a slight darkening of the red over affected spots, or sometimes a faint tinge of the purple (pl. 10, *B*). A superficial growth of white mold, rare in the field, is frequently seen on affected fruit on the market.

In cross and longitudinal sections, strawberries affected by leather rot show a marked browning of the water-conducting system, accompanied usually by a less intense browning of all the other tissues (pl. 10, *C*). In very early stages this browning in the vessels is often the only visible symptom. There is no clear line of demarcation between diseased and healthy flesh and the two cannot be separated by mechanical means; it is not possible to lift or scoop out the part affected as can so easily be done with the rotten spots produced by *Rhizopus*.

Causal Factors

The fungus that causes leather rot is able to penetrate the uninjured skin of strawberry fruits. The disease has always been found associated with wet weather in the field and for that reason is known to growers as water soak. Leather rot is also favored by moderately high temperatures. Very little of this rot develops when rain is followed by cool weather, but when rain is followed by warm periods, leather rot may cut down the marketable crop by 20 percent or more. In berries exposed to warm weather following heavy rains, leather rot does not appear until about the third day after the rain and becomes most prevalent about the fourth or fifth day. When a heavy rain is followed by dry weather for a week or more, the last traces of leather rot, in the field, may be expected to disappear by the seventh or eighth day.

Control Measures

Precooling strawberries to 40° F. or lower and keeping them below 40° in transit reduces the development of leather rot to a minimum. Some control of leather rot is obtained by field mulching or the use of treated paper or polyethylene materials under the plants, which keeps the berries from coming in contact with the soil.

(See *47*, *124*, *125*, *126*.)

RHIZOCTONIA ROT

(*Rhizoctonia solani* Kuehn)

Occurrence and Symptoms

Rhizoctonia rot is known to occur in central Florida, North Carolina, Tennessee, and Arkansas. In rainy seasons strawberries from all these districts show this rot on the market, sometimes in such percentage that their market value is seriously reduced. All varieties grown where the rot occurs are susceptible.

Affected berries are usually one-sided and show a decayed spot to which soil often adheres. Affected tissues are dry, spongy, and dark-brown to black. There is usually a distinct margin between decayed and sound tissues. Infection begins on the under side where the berry touches the soil, usually before it begins to turn red and sometimes before it is a third grown. Early infection results in deformed fruits, but since the rot develops slowly there may be no sign of it on the upper side of the berry. Consequently it is difficult to keep affected fruit out of the pack (pl. 10, *D*).

The rot is caused by *Rhizoctonia solani*, a soil fungus, which is the cause of disease in a number of other plants. A study of artificially inoculated strawberries shows that infection takes place in the small pits in which the seeds are embedded; it is not known whether the hyphae can penetrate the uninjured epidermis or are dependent on wounds for an entrance.

Cultural practices such as mulching to prevent the fruit from coming in contact with the soil, prompt precooling, and transit refrigeration are probably the best means of control. When fruit is held below 40° F., there is little danger of the disease spreading from diseased to healthy berries.

RHIZOPUS ROT

(*Rhizopus nigricans* Fr.)

Occurrence and Symptoms

The fungus *Rhizopus* has a wide distribution in nature and attacks many kinds of fruit, probably causing more post-harvest losses than all other decay organisms combined.

Rhizopus causes a very soft rot of strawberries sometimes known as "leak", the name having originated from the fact that the fungus, as it spreads through the fruit, breaks down the tissues and allows the juice to escape. In late stages there is almost always an odor of fermentation, but at no time does the fungus produce the marked browning that is characteristic of this type of decay in some other fruits.

Causal Factors

The cause of Rhizopus rot of strawberries is designated as *Rhizopus nigricans*, although other species are sometimes involved. At room temperature the fungus is characterized by a heavy growth of coarse white mold and small spherical spore-bearing heads which are white and glistening when young, but later become black and dull (pl. 9, *A*, *B*). Under moderate refrigeration in storage or transit only a scant growth of mold is produced and the heads are formed in dense gray or black masses near to the surface of the fruit.

In warm wet weather, Rhizopus rot is occasionally found on strawberries in the field. Rains followed by temperatures above 70° F. favor infection, but most of the decay develops during transit and marketing. Spores on the surface of the berries readily germinate under favorable conditions, causing new infections, particularly in injured or bruised tissue. The mold spreads rapidly from diseased berries to others lying near or touching them.

The development and spread of Rhizopus rot is greatly favored by water on the fruit, provided the temperature of the fruit is moderately high. Investigations in a number of States have shown, however, that there is a distinct advantage in picking strawberries in the morning when they are cool even though they may be wet from rain or dew. Such berries are 15 to 20 degrees cooler than those picked a few hours later and, when used in test shipments, have always been found to arrive on the market with less rot than the fruit harvested later in the day.

Control Measures

The incidence of Rhizopus rot in transit is favored by the presence of skin breaks and moisture, but temperature is the critical factor determining its development. Rhizopus rot can develop at temperatures slightly above 50° F., but refrigerating strawberries below 50° protects them from this particular type of decay. Berries should be held below 40° to retard the development of other types of decay, however. Any delay in cooling provides an opportunity for the rot to develop. In California strawberries are usually precooled before loading into railway express cars or trucks. In areas where berries are loaded warm into the cars, precooling should be started immediately after loading.

(See *32*, *43*, *47*, *59*, *71*, *72*, *125*, *126*, *127*, *146*, *148*, *149*, *153*, *154*, *157*, *160*, *175*.)

SCLEROTINIA ROT

(*Sclerotinia* sp., probably *S. sclerotiorum* (Lib.) d By.)

Strawberries affected with Sclerotinia rot are firm, but rather watery and usually show small patches of a white, cottony, fungus growth that becomes quite luxuriant if the berries are held under moist conditions. If held in a dry place, the berries shrivel, the fungus growth collapses, and hard, rounded black masses known as sclerotia or resting bodies are formed.

The disease occurs in various sections of the South, but is not often seen on the market. Losses caused by it are probably not large.

STEM-END ROT

(*Dendrophoma obscurans* (Ell. & Ev.) H. W. Anderson)

Strawberries in Michigan and eastern Canada are sometimes attacked by *Dendrophoma*. Another organism, *Gnomonia fragariae* Kleb., is often associated with the disease. The fungus frequently becomes established first on the calyx from which it spreads to the fruit, causing a rot at the stem-end. The fruit may also be attacked directly. When mature berries are affected they soften, turn brown, and the rot gradually spreads over the entire berry. There is usually a distinct margin between the diseased and healthy tissue. Small brownish fruiting bodies (pycnidia) are produced on affected areas. These frequently appear first under the calyx, but later are produced elsewhere on the berry.

Little is known regarding control measures against the disease.

(See *1*, *2*, *5*, *27*, *58*, *60*.)

TAN BROWN ROT

(*Discohainesia oenotherae* (Cke. & Ell.) Nannf.)

Occurrence and Symptoms

Tan brown rot of strawberries has been found in Cuba, Louisiana, Florida, Arkansas, Tennessee, Virginia, Maryland, Ohio, Wisconsin, Oregon, and Alaska. When field and transit conditions are favorable for its development it may cause serious losses in fruit shipped to the market.

Symptoms on both green and ripe fruit are sunken, softened, tan-colored spots (pl. 10, *E*), which extend more deeply into the flesh of the berry than might be suspected from their surface diameter. The rotted tissues are throughly permeated and held together by the fungus, forming a core that easily can be removed intact. The spots vary in diameter from about ¼ to ½ inch, but may be larger on ripe fruit because the fungus has had a longer time to grow and the development of the rot on ripe fruit is more rapid than on less mature berries.

Causal Factors

Tan brown rot is caused by the fungus *Discohainesia oenotherae*, which also is found on about 50 different host plants widely distributed throughout North and South America and Europe. It is a weak parasite that usually, perhaps always, is dependent on some injury to gain entrance into the host. Development of the rot is favored by warm, wet weather.

Control Measures

Mulching with pine needles or straw is apparently the only method of controlling tan brown rot in the field. The use of paper or plastic film to keep the berries off the ground serves the same purpose. Control in transit and on the market depends on careful handling, temperatures blow 40° F., and prompt movement of the shipments.

(See *32*, *47*, *145*, *149*.)

LITERATURE CITED

(1) ALEXOPOULOS, C. J., and CATION, D.
1948. STEM-END ROT OF STRAWBERRIES. Phytopathology 38: 698–706.

(2) ———, and CATION, D.
1952. GNOMONIA FRAGARIAE IN MICHIGAN. Mycologia 44: 221–223.

(3) ALLEN, F. W. and PENTZER, W. T.
1950. (COLD STORAGE OF) APPLES, PEARS, AND GRAPES. IN THE REFRIGERATING DATA BOOK. Amer. Soc. Refrigerating Engin., New York, pp. 173–187.

(4) ANDERSON, H. W.
1947. STRAWBERRY FRUIT ROTS AND THEIR CONTROL. Ill. State Hort. Soc. Trans. (1946) 80: 239–243.

(5) ———
1956. DISEASES OF FRUIT CROPS. McGraw-Hill Co. 501 pp., illus. New York.

(6) ———, and COLBY, A. S.
1943. DEAD ARM DISEASE OF GRAPE IN ILLINOIS. U.S. Bur. Plant Indus., Soil, and Agr. Engin., Plant Dis. Rptr. 27: 245–246.

(7) ANDERSON, P. J.
1924. BOTRYTIS CINEREA IN ALASKA. Phytopathology 14: 152–155.

(8) ANONYMOUS.
1959. PEST CONTROL PROGRAM FOR GRAPES. Calif. Agr. Expt. Sta. Leaf. 79.

(9) APP, J., LORANT, G. J., WORTHINGTON, O. J., and others.
1951. MORE STORAGE TIME FOR GRAPES. Ice and Refrig. 129: 43–45.

(10) BAILEY, J. S.
1948. FURTHER OBSERVATIONS OF MUMMY BERRY ON CULTIVATED BLUEBERRIES. Amer. Soc. Hort. Sci. Proc. 52: 299–303.

(11) ———, and SPROSTON, THOMAS
1946. FERMATE FOR THE CONTROL OF MUMMY BERRY OF THE CULTIVATED BLUEBERRY. Amer. Soc. Hort. Sci. Proc. 47: 209–212.

(12) BAIN, H. F.
1926. CRANBERRY DISEASE INVESTIGATIONS ON THE PACIFIC COAST. U.S. Dept. Agr. Bul. 1434, 29 pp.

(13) BAKER, R. E., and BUTTERFIELD, H. M.
1951. COMMERCIAL BUSHBERRY GROWING IN CALIFORNIA. Univ. Calif. Agr. Ext. Serv. Cir. 169. 50 pp.

(14) Barrett, H. C.
1953. black rot resistance in grapes. Univ. Ill. Diss. Abstr., 13: 2.

(15) ———
1953. a large-scale method of inoculating grapes with the black rot organism. U.S. Bur. Plant Indus., Soils, and Agr. Engin., Plant Dis. Rptr. 37: 159.

(16) Barta, Edward J., Wolford, E. R., and Lowe, E.
1951. treatment of berry boxes (hallocks) to reduce mold growth. Food Tech. 5: 512–517.

(17) Beneke, E. S., and Young, W. J.
1952. reducing mold counts in canned or frozen black raspberries. (Abstract) Phytopathology 42: 2.

(18) Bergman, H. F.
1935. cooperative cranberry investigations. Mass. Agr. Expt. Sta. (Ann. Rpt. 1934) Bul. 315: 32–34.

(19) ———, and Wilcox, M. S.
1936. the distribution, cause, and relative importance of cranberry fruit rots in massachusetts in 1932 and 1933, and their control by spraying. Phytopathology 26: 656–664.

(20) Berry, J. A., and Magoon, C. A.
1934. growth of microorganisms at and below 0° c. Phytopathology 24: 780–796.

(21) Beyers, E.
1939. further investigations of factors affecting "drop" and desiccation of stalks of waltham cross in storage. Union So. Africa, Dept. Agr. and Forestry, Ann. Rpt. Low Temp. Research Lab., Capetown, 1937–38: 79–87.

(22) Bioletti, F. T.
1907. oidium or powdery mildew of the vine. Calif. Agr. Expt. Sta. Bul. 186, pp. (315)–352, illus.

(23) ———
1923. black measles, water berries, and related vine troubles. Calif. Agr. Expt. Sta. Bul. 358, pp. 509–524, illus.

(24) ———, and Flossfeder, F. C. H.
1915. oidium or powdery mildew of the vine. Calif. Agr. Expt. Sta. Cir. 144, 12 pp.

(25) Blumer, S.
1947. versuche zur bekämpfung der graufäule (botrytis cinerea). Schweiz. Ztschr. f. Obst u. Weinbau, 56: 51–61.

(26) ———
1951. die bekämpfung der krankheiten und schädlinge im rebbau. Schweiz. Ztschr. f. Obst. u. Weinbau, 60: 173–179.

(27) Bolton, A. T.
1954. gnomonia fructicola on strawberry. Canadian Jour. Bot. 32: 172–181.

(28) Bonnet, L. O.
1926. a promsing remedy for black measles of the vine. Calif. Agr. Expt. Sta. Cir. 303, 10 pp., illus.

(29) ———
1928. enemies of the flower and fruit. Calif. Grape Grower 9(3): 6, 7.

(30) Braun, A. J.
1949. plant pathology. Rpt. N.Y. State Agr. Expt. Sta., 1948, 67: 26–33.

(31) ———
1950. plant pathology. Rpt. N.Y. State Agr. Expt. Sta., 1949, 68: 20–28.

(32) Brooks, A. N., Watson, J. R., and Mowry, Harold.
1929. strawberries in florida. Culture, diseases, and insects. Fla. Agr. Expt. Sta. Bul. 204, pp. (481)–523, illus.

(33) Brooks, Charles, Bratley, C. O., and McColloch, L. P.
1936. transit and storage diseases of fruits and vegetables as affected by initial carbon dioxide treatments. U.S. Dept. Agr. Tech. Bul. 519, 24 pp.

(34) Brooks, Charles, Miller, E. V., Bratley, C. O., and others.
1932. EFFECT OF SOLID AND GASEOUS CARBON DIOXIDE UPON TRANSIT DISEASES OF CERTAIN FRUITS AND VEGETABLES. U.S. Dept. Agr. Tech. Bul. 318, 59 pp.

(35) Buchwald, N. F.
1949. STUDIES IN THE SCLEROTINIACEAE. I. TAXONOMY OF THE SCLEROTINIACEAE. Vet. Hojsk Aarsskr. 1949, pp. 75–191.

(36) Butler, E. J. and Jones, S. G.
1949. PLANT PATHOLOGY. 979 pp., illus. London.

(37) Chiarappa, Luigi.
1959. WOOD DECAY OF GRAPE VINES AND ITS RELATIONSHIP WITH BLACK MEASLES DISEASE. Phytopathology 49: 510–519.

(38) Darrow, G. M. and Detwiler, S. B.
1924. CURRANTS AND GOOSEBERRIES: THEIR CULTURE AND RELATION TO WHITE-PINE BLISTER RUST. U.S. Dept. Agr. Farmers' Bul. 1398, 42 pp., illus. (Revised 1934)

(39) ———, and Waldow, G. F.
1932. EFFECT OF FERTILIZERS ON PLANT GROWTH, YIELD AND DECAY OF STRAWBERRIES IN NORTH CAROLINA. Amer. Soc. Hort. Sci. Proc. 29: 318–324.

(40) ———, Wilcox, R. B. and Beckwith, C. S.
1944. BLUEBERRY GROWING. U.S. Dept. Agr. Farmers' Bul. 1951, 38 pp.

(41) Delp, C. J.
1954. EFFECT OF TEMPERATURE AND HUMIDITY ON THE GRAPE POWDERY MILDEW FUNGUS. Phytopathology 44: 615–626.

(42) ———. Hewitt, W. B., and Nelson, K. E.
1951. CLADOSPORIUM ROT OF GRAPES IN STORAGE. (Abstract) Phytopathology 41: 937–938.

(43) Demaree, J. B.
1941. DISEASES OF STRAWBERRIES. U.S. Dept. Agr. Farmers' Bul. 1891, 27 pp., illus.

(44) ———. and Still, G. W.
1951. CONTROL OF GRAPE DISEASES AND INSECTS IN EASTERN UNITED STATES. U.S. Dept. Agr. Farmers' Bul. 1893, 36 pp.

(45) ———, and Wilcox, M. S.
1947. FUNGI PATHOGENIC TO BLUEBERRIES IN THE EASTERN UNITED STATES. Phytopathology 37: 487–506.

(46) Dewey, D. H.
1952. AMMONIA DAMAGE TO STORED FRUITS AND NUTS; SULFUR DIOXIDE AS A CORRECTIVE TREATMENT. Ice and Refrig. 123(3): 19–22.

(47) Dodge, B. O. and Stevens, N. E.
1924. THE RHIZOCTONIA BROWN ROT AND OTHER FRUIT ROTS OF STRAWBERRIES. Jour. Agr. Res. 28: 643–648, illus.

(48) ———, and Wilcox, R. B.
1941. DISEASES OF RASPBERRIES AND BLACKBERRIES. U.S. Dept. Agr. Farmers' Bul. 1488, 33 pp.

(49) Donen, I.
1942. MOULD CONTROL IN GRAPES. RESULTS OBTAINED WITH THE USE OF SULPHUR DIOXIDE. Farming in So. Africa 17(192): 199–208.

(50) Driggers, B. F.
1927. A COMPARISON OF DUSTS AND SPRAY TO CONTROL FUNGUS DISEASES OF THE CRANBERRY. N.J. Agr. Expt. Sta. Bul. 450, 16 pp.

(51) Dufrenoy, J., and Genevois, L.
1935. DEVELOPPEMENT DU CLADOSPORIUM HERBARUM SUR DES RAISINS A BASSE TEMPERATURE. C. R. Soc. Biol. Paris 118: 708–710.

(52) Dunne, T. C.
1940. WASTAGE IN EXPORT GRAPES. PRELIMINARY STUDIES WITH POTASSIUM METABISULPHITE. Jour. Dept. Agr., W. Aust., pp. 439–443.

(53) DuPlessis, S. J.
1936. STUDIES ON THE WASTAGE OF EXPORT GRAPES WITH SPECIAL REFERENCE TO THAT CAUSED BY BOTRYTIS CINEREA PERS. Union So. Africa Dept. Agr. and Forestry Sci. Bul. 151, 163 pp., illus.

(54) ———
1940. ANTHRACNOSE OF THE VINE. Farming in So. Africa 15(168): 97–100, 104.

(55) DUPLESSIS, S. J.
1943. SWAWEL VIR DIE BESTRYDING VAN WINGERDSIEKTES. (SULFUR FOR THE CONTROL OF VINEYARD DISEASES.) Farming in So. Africa 43(207): 472–474, 477.

(56) ———
1950. THREE IMPORTANT VINE DISEASES WITH PARTICULAR REFERENCE TO BACTERIAL BLIGHT, AND FACTS ABOUT VINEYARDS AND VINE NURSERIES IN SOUTH AFRICA. Union of So. Africa Dept. Agr., Sci. Bul. 323, 30 pp., illus.

(57) EGLITIS, MAKSIS, JOHNSON, FOLKE, and CROWLEY, D. C.
1952. STRAINS OF BOTRYTIS PATHOGENIC TO BLUEBERRIES. (Abstract) Phytopathology 42: 513.

(58) FALL, J. E.
1951. STUDIES ON FUNGUS PARASITES OF STRAWBERRY LEAVES IN ONTARIO. Canadian Jour. Bot. 29: 299–315.

(59) FISHER, D. F. and LUTZ, J. M.
1937. HANDLING AND SHIPPING STRAWBERRIES WITHOUT REFRIGERATION. U.S. Dept. Agr. Cir. 515, 16 pp., illus.

(60) FULTON, R. H.
1956. HOW TO RECOGNIZE AND CONTROL STRAWBERRY FRUIT ROTS. Michigan State Ext. Folder F–220. 6 pp.

(61) ———
1957. HOW TO RECOGNIZE AND CONTROL RASPBERRY ANTHRACNOSE. Michigan State Ext. Folder F–219. 6 pp.

(62) ———
1958. HOW TO RECOGNIZE AND CONTROL BLACK ROT OF GRAPE. Michigan State Univ. Ext. Folder F–256. 8 pp.

(63) GEARD, I. D.
1955. PROGRESS REPORT ON BERRY FRUIT SPRAYING TRIALS. Tasmanian Jour. Agr. 26(3): 243–253.

(64) GLADWIN, F. E.
1928. DOWNY AND POWDERY MILDEWS OF THE GRAPE AND THEIR CONTROL. N.Y. State Agr. Expt. Sta. Bul. 560, 14 pp.

(65) GOHEEN, A. C.
1950. BLUEBERRY SPOILAGE IN COLD STORAGE. N.J. Agr. Expt. Sta., 19th Annual Blueberry Open House, Proc. pp. 2–5.

(66) GREGORY, C. T.
1913. A ROT OF GRAPES CAUSED BY CRYPTOSPORELLA VITICOLA. Phytopathology 3: 20–23.

(67) HARVEY, J. M.
1955. DECAY IN STORED GRAPES REDUCED BY FIELD APPLICATIONS OF FUNGICIDES. Phytopathology 45: 137–140.

(68) ———
1955. A METHOD OF FORECASTING DECAY IN CALIFORNIA STORAGE GRAPES. Phytopathology 45: 229–232.

(69) ———
1959. REDUCTION OF DECAY IN STORAGE GRAPES BY FIELD APPLICATIONS OF CAPTAN. U.S. Dept. Agr. Plan Disease Rptr. 43: 889–891.

(70) HAYNES, R. D., HARLIN, HARRIET, MUNDT, J. O., and STOKES, ROY
1953. THE USE OF DETERGENTS IN REMOVING MOLD FROM STRAWBERRIES. Quick Frozen Foods 15(7): 53–54, 56.

(71) HEALD, F. D.
1933. MANUAL OF PLANT DISEASES. Ed. 2, 953 pp., illus. New York and London.

(72) HESLER, L. R. and WHETZEL, H. H.
1917. MANUAL OF FRUIT DISEASES. 462 pp., illus., New York.

(73) HEWITT, W. B.
1947. SODIUM ARSENITE, A PROMISING CONTROL OF DEAD-ARM OF GRAPES. (Abstract) Phytopathology 37: 362.

(74) ———
1951. GRAPE DEAD-ARM CONTROL. U.S. Bur. Plant Indus., Soils, and Agr. Engin., Plant Dis. Rptr. 35: 142–143.

(75) ———
1952. SOME RESPONSES OF GRAPEVINES TO SODIUM ARSENITE SPRAY APPLIED FOR BLACK MEASLES CONTROL. Phytopathology 42: 158–161.

(76) HOCKY, J. F.
1952. GREY MOULD WILT OF RASPBERRY. Sci. Agr. 32(3): 150–152.

(77) HORN, N. L.
1952. STRAWBERRY FUNGICIDE SCREENING TESTS. U.S. Bur. Plant Indus., Soils, and Agr. Engin., Plant Dis. Rptr. 36: 309–310.

(78) HRUSCHKA, H. W., and KAUFMAN, J.
1951. STORAGE TESTS WITH PREPACKAGED MCFARLIN AND LATE HOWES CRANBERRIES. 1950–1951. U.S. Dept. of Agr., Handling, Transportation & Storage Office Rpt. 248, 5 pp.

(79) ———, KAUFMAN, J., REDIT, W. H. and others.
1955. EFFECTS OF PRECOOLING, SALTING, CARTON VENTILATION, AND LOAD PATTERN ON TEMPERATURE, MOISTURE CONDENSATION AND SPOILAGE IN RAIL SHIPMENTS OF PREPACKAGED EARLY BLACK MASSACHUSETTS-GROWN CRANBERRIES. U.S. Dept. Agr., AMS-43, 23 pp.

(80) JACOB, H. E.
1929. POWDERY MILDEW OF THE GRAPE AND ITS CONTROL IN CALIFORNIA. Calif. Col. Agr. Ext. Cir. 31, 18 pp., illus.

(81) ———
1929. THE USE OF SULFUR DIOXIDE IN SHIPPING GRAPES. Calif. Agr. Expt. Sta. Bul. 471, 24 pp., illus.

(82) ——— and WINKLER, A. J.
1950. GRAPE GROWING IN CALIFORNIA. Calif. Agr. Ext. Serv. Cir., 116, 80 pp.

(83) JENKINS, A. E. and BITANCOURT, A. A.
1943. GOUIRAND AND BERGERON'S TREATMENT OF SPHACELOMA AMPELINUM. Mycologia 35: 272–276.

(84) JENKINS, W. A.
1941. DISEASES OF MUSCADINE GRAPES. In Savage, E. F., *et al.*, FURTHER STUDIES WITH THE MUSCADINE GRAPE. Ga. Agr. Expt. Sta. Bul. 217: 19–29.

(85) ———
1941. SOME LEAF SPOTS AND BERRY ROTS OF MUSCADINE GRAPES IN GEORGIA. (Abstract) Phytopathology 31: 767–768.

(86) KIRBY, A. H. M., MOORE, M. H., and WILSON, D. J.
1955. STRAWBERRY BOTRYTIS ROT (GREY MOULD) CONTROL: A FIELD TRIAL OF CAPTAN AT EAST MALLING. J. Hort. Sci. 30(4): 220–224.

(87) LOUCKS, K. W.
1936. SPRAYING EXPERIMENTS FOR THE CONTROL OF CERTAIN GRAPE DISEASES. Fla. Agr. Expt. Sta. Bul. 294, 16 pp.

(88) LUTTRELL, E. S.
1946. BLACK ROT OF MUSCADINE GRAPES. Phytopathology 36: 905–924.

(89) ———
1948. BOTRYOSPHAERIA RIBIS, PERFECT STAGE OF THE MACROPHOMA CAUSING RIPE ROT OF MUSCADINE GRAPES. Phytopathology 38: 261–263.

(90) ———
1953 MELANCONIUM LEAF ANE STEM FLECK OF GRAPES. Phytopathology 43: 347–348.

(91) ——— and MURPHY, M. M.
1948. BOTANY. Ga. Expt. Sta. Rpt., 1947–8. pp. 62–68.

(92) ———, and MURPHY, M. M.
1953. EFFECT OF SPRAYING ON INCIDENCE OF DISEASES AND YIELDS OF MUSCADINE GRAPES. Phytopathology 43: 629–633.

(93) MALAN, H.
1954. LONG-TERM STORAGE OF GRAPES. Farming in So. Africa 29(335): 157–159.

(94) MANNS, T. F.
1935. FACTORS CONCERNED IN THE CONTROL OF BLACK ROT OF GRAPE. Peninsula Hort. Soc. (Del.) Trans. 49: 55–57.

(95) MARSH, R. W., MARTIN, J. T. and CRANG, ALICE.
1955. THE CONTROL OF BOTRYTIS ROT (GREY MOULD) OF STRAWBERRIES, AND THE EFFECTS OF FUNGICIDE SPRAY RESIDUES ON THE PROCESSED FRUIT. J. Hort. Sci. 30(4): 225–233.

(96) McClintock, J. A.
1946. Spraying for strawberry fruit rots in 1946. Hoosier Hort. 28(10): 147–148.
(97) Müller-Stoll, W. R.
1950. Versuche zum Problem der Wirksamkeit von Seifen- und Seifenersatzmitteln gegen den Traubenschimmel (Botrytis cinerea). Phytopath. Ztschr. 17: 265–286.
(98) Narasimham, K. L., Bedford, C. L. and Robertson, W. F.
1954. The effect of harvesting conditions on mold count of black raspberries. Mich. Agr. Expt. Sta. Quart. Bul. 36: 280–284.
(99) Nelson, K. E.
1951. Factors influencing the infection of table grapes by Botrytis cinerea. Phytopathology 41: 319–326.
(100) ———
1951. Effect of humidity on infection of table grapes by Botrytis cinerea. Phytopathology 41: 859–864.
(101) ———, Hewitt, W. B. and Break, R. A.
1949. Arsenite spray injury to grape canes through leaf scars. Phytopathology 39: 71–76.
(102) Osterwalder, A.
1943. Von teilweisen Lahmstieler-Trauben. (On grapes with partial pedicel lameness). Schweiz. Ztschr. f. Obst u. Weinbau. 52: 635–638.
(103) Paris, G. K. and Stover, L. H.
1947. Spraying grapes for disease control in Florida 1945–1947. Fla. Hort. Soc. Proc., 1947: 93–94.
(104) Pelletier, E. N. and Hilborn, M. T.
1954. Blossom and twig blight of low-bush blueberries. Maine Agr. Expt. Sta. Bul. 529, 27 pp.
(105) Pentzer, W. T.
1939. Methods of applying sodium bisulphite to grape packages for mold control. Blue Anchor 16(7): 2.
(106) ———, and Asbury, C. E.
1934. Sulphur dioxide as an aid in the preservation of grapes in transit and storage. Blue Anchor 11(8): 2–4, 23, illus.
(107) ———, and Asbury, C. E.
1935. The sodium bisulphite treatment of grapes to retard mold growth. Blue Anchor 12(5): 6, 26, 27.
(108) ———, Asbury, C. E. and Hammer, K. C.
1933. Effects of fumigation of different varieties of vinifera grapes with sulphur dioxide gas. Amer. Soc. Hort. Sci. Proc. (1932) 29: 339–344, illus.
(109) ———, and Barger, W. R.
1941. A comparison of fungicidal treatments for the control of Botrytis rot of grapes in storage. Amer. Soc. Hort. Sci. Proc. 39: 280–284.
(110) Powell, Dwight.
1952. The effect of early spring fungicides on Botrytis cinerea. U.S. Bur. Plant Indus., Soils, and Agr. Engin., Plant Dis. Rptr. 36: 97–98.
(111) ———
1953. An evaluation of chemical treatment for the control of Botrytis cinerea on strawberry. (Abstract) Phytopathology 43: 482.
(112) ———
1954. The effect of captan on grey mould rot incidence and yield of strawberry. U.S. Bur. Plant Indus., Soils, and Agr. Engin., Plant Dis. Rptr. 38: 209–211.
(113) Quaintance, A. L. and Shear, C. L.
1921. Insect and fungous enemies of the grape. U.S. Dept. Agr. Farmers' Bul. 1220, 75 pp. illus.
(114) Rattray, J. M.
1938. Grape wastage investigations, 1937. Union So. Africa, Dept. Agr. and Forestry, Ann. Rpt. Low Temp. Research Lab., Capetown, 1936–37: 75–91.

(115) RATTRAY, J. M.
1939. GRAPE WASTAGE INVESTIGATIONS, 1938. Union So. Africa, Dept. Agr. and Forestry, Ann. Rpt. Low Temp. Research Lab., Capetown, 1937–38: 65–74.

(116) ———
1940. THE EFFECT OF SO_2 GENERATING TABLETS. Union So. Africa, Dept. Agr. and Forestry, Ann. Rpt. Low Temp. Research Lab., Capetown, 1938–39: 48–60.

(117) REDDICK, DONALD.
1911. THE BLACK ROT DISEASE OF GRAPES. Cornell Univ. Agr. Expt. Sta. Bul. 293, 364 pp., illus.

(118) REYNEKE, J. and PIAGET, J. E. H.
1952. THE USE OF BISULPHITES IN THE CONTROL OF WASTAGE IN FRESH GRAPES. Farming in So. Africa 27(319): 477–479.

(119) RHOADS, A. S.
1923. NOTES ON THE FAILURE OF GRAPEVINES TO SET FRUIT AND ON SHELLING. Phytopathology 13: 513–519.

(120) ———
1924. RIPE ROTS OF GRAPES AND THE COPPER ACETATES AS NONSTAINING SPRAYS FOR LATE APPLICATIONS TO CONTROL THEM. Fla. State Plant Board Quart. Bul. 8: 97–102.

(121) ———
1924. GRAPE DISEASES WITH SPECIAL REFERENCE TO BLACK ROT AND ANTHRACNOSE. Fla. State Plant Board Quart. Bul. 8: 102–112.

(122) ———
1926. DISEASES OF GRAPES IN FLORIDA. Fla. Agr. Expt. Sta. Bul. 178, 82 pp.

(123) RICHARDS, M. C.
1946. SPRAYING GRAPES TO CONTROL BLACK ROT. U.S. Bur Plant Indus., Soils, and Agr. Engin., Plant Dis. Rptr. 30: 464.

(124) ROSE, D. H.
1924. LEATHER ROT OF STRAWBERRIES. Jour. Agr. Res. 28: 357–376, illus.

(125) ———
1926. RELATION OF STRAWBERRY FRUIT ROTS TO WEATHER CONDITIONS IN THE FIELD. Phytopathology 16: 229–232.

(126) ———
1926. DISEASES OF STRAWBERRIES ON THE MARKET. U.S. Dept. Agr. Cir. 402, 8 pp., illus.

(127) ———, and GORMAN, E. A., JR.
1936. HANDLING, PRECOOLING, AND TRANSPORTATION OF FLORIDA STRAWBERRIES. U.S. Dept. Agr. Tech. Bul. 525, 58 pp., illus.

(128) ———, and PENTZER, W. T.
1947. COMMERCIAL METHODS OF FUMIGATING GRAPES WITH SULPHUR DIOXIDE. The Blue Anchor. 24(4): 6–7, 34.

(129) RYALL, A. L. and HARVEY, J. M.
1959. THE COLD STORAGE OF VINIFERA GRAPES. U.S. Dept. Agr. Handbook 159. 46 pp.

(130) SCHELLENBERG, A.
1955. KULTURMASSNAHMEN ZUR VERMINDERUNG DER TRAUBENFÄULNIS. Schweiz. Ztschr. f. Obst. u. Weinbau. 64: 107–112.

(131) SHEAR, C. L.
1917. ENDROT OF CRANBERRIES. Jour. Agr. Res. 11: 35–41.

(132) ———
1929. THE LIFE HISTORY OF SPHACELOMA AMPELINUM DE BARY. Phytopathology 19: 673–679.

(133) ———, and BAIN, H. F.
1929. LIFE HISTORY AND PATHOLOGICAL ASPECTS OF GODRONIA CASSANDRAE PECK (FUSICOCCUM PUTREFACIENS SHEAR) ON CRANBERRY. Phytopathology 19: 1017–1024.

(134) ———, STEVENS, N. E., and BAIN, H. F.
1931. FUNGOUS DISEASES OF THE CULTIVATED CRANBERRY. U.S. Dept. Agr. Tech. Bul. 258, 58 pp.

(135) ———, STEVENS, N. E., and RUDOLPH, B. A.
1917. OBSERVATIONS ON THE SPOILAGE OF CRANBERRIES DUE TO LACK OF VENTILATION. Mass. Agr. Expt. Sta. Bul. 180: (235)–239.

(136) Shear, C. L., Stevens, N. E., Wilcox, R. B., and Rudolph, B. A.
1918. spoilage of cranberries after harvest. U.S. Dept. Agr. Bul. 714, 20 pp.
(137) Smith, R. E.
1941. diseases of fruits and nuts. Calif. Agr. Ext. Serv. Cir. 120, 168 pp.
(138) Smith, W. H.
1952. deterioration in fruits and vegetables during marketing. Fruit Grower 1952 (2949) : 22–23.
(139) ———
1957. the application of precooling and carbon dioxide treatment to the marketing of strawberries and raspberries. Sci. Hort. 12(1) : 147–153.
(140) Sprague, Roderick.
1953. field rots of grapes in north-central washington. Northwest Science 27 : 1–16.
(141) Staehelin, M.
1946. station federale d'essais viticoles et arboricoles et de chimie agricole, à lausanne et à pully. rapport d'activité 1945. Ann. Agr. Suisse. 47(8) : 741–842.
(142) ———, and Wurgler, W.
1947. stations federales d'essais viticoles, arboricoles et de chimie agricole, à lausanne et à pully. rapport d'activité 1946. Ann. Agr. Suisse. 48 (8–9) : 701–792.
(143) Stalder, L.
1953. untersuchungen über die graufäule (botrytis cinerea pers.) an trauben. 1. mitteilung. Phytopath. Ztschr. 20: 315–344.
(144) ———
1953. witterung und traubenfäulnis. Schweiz. Ztschr. f. Obst. u. Weinbau. 62: 477–484.
(145) Stevens, F. L., and Peterson, Alvah.
1916. some new strawberry fungi. Phytopathology 6: 258–267.
(146) Stevens, N. E.
1916. pathological histology of strawberries affected by species of botrytis and rhizopus. Jour. Agr. Res. 6: 361–366.
(147) ———
1917. temperatures of the cranberry regions of the united states in relation to the growth of certain fungi. Jour. Agr. Res. 11: 521–529.
(148) ———
1919. keeping quality of strawberries in relation to their temperature when picked. Phytopathology 9: (171)–177.
(149) ———
1922. rots of early strawberries in florida and southern california. Amer. Jour. Bot. 9: 204–211, illus.
(150) ———
1924. notes on cranberry fungi in massachusetts. Phytopathology 14: 101–107.
(151) ———
1929. a method of testing the keeping quality of certain small fruits. Phytopathology 19: 593–596.
(152) ———
1932. market diseases of strawberries from the southeastern states, 1926 to 1930. U.S. Dept. Agr. Cir. 219, 4 pp.
(153) ———
1932. keeping quality as a factor in selecting new varieties of small fruits. Phytopathology 22: 715–719.
(154) ———
1935. strawberry diseases. U.S. Dept. Agr. Farmers' Bul. 1458, 10 pp., illus.
(155) ———, and Bergman, H. F.
1921. the relation of water raking to the keeping quality of cranberries. U.S. Dept. Agr. Bul. 960, 12 pp.
(156) ———, and Chivers, A. H.
1919. fanning strawberries in relation to keeping quality. Phytopathology 9: 547–553.

(157) STEVENS, N. E., and HAWKINS, L. A.
1917. SOME CHANGES PRODUCED IN STRAWBERRY FRUITS BY RHIZOPUS NIGRICANS. Phytopathology 7: (178)-184.

(158) ———, and HAWKINS, L. A.
1925. GROWTH OF BOTRYTIS ON STRAWBERRIES UNDER REFRIGERATION. Ice and Refrig. 69: 375-376, illus.

(159) ———, and MORSE, F. W.
1919. THE EFFECT OF THE ENDROT FUNGUS ON CRANBERRIES. Amer. Jour. Bot. 6: 235-241.

(160) ———, and WILCOX, R. B.
1917. RHIZOPUS ROT OF STRAWBERRIES IN TRANSIT. U.S. Dept. Agr. Bul. 531, 22 pp., illus.

(161) ———, and WILCOX, R. B.
1917. FURTHER STUDIES OF THE ROTS OF STRAWBERRY FRUITS. U.S. Dept. Agr. Bul. 686, 14 pp.

(162) ———, and WILCOX, R. B.
1918. TEMPERATURES OF SMALL FRUITS WHEN PICKED. The Plant World. 21: 176-183.

(163) SUIT, R. F.
1945. FIELD RESULTS ON THE CONTROL OF CERTAIN GRAPE DISEASES IN NEW YORK. N.Y. State Agr. Expt. Sta. Bul. 712, 26 pp.

(164) SWARTWOUT, H. G.
1941. SPRAYING GRAPES WITH SPECIAL REFERENCE TO BLACK ROT. Mo. Agr. Expt. Sta. Cir. 211, 4 pp.

(165) THOMAS, H. E.
1939. THE PRODUCTION OF STRAWBERRIES IN CALIFORNIA. Calif. Agr. Ext. Serv. Cir. 113, 92 pp.

(166) UOTA, M. and COOK, F. L.
1958. IMPROVED METHODS NEEDED FOR SO_2 GRAPE FUMIGATION. Blue Anchor 35(3): 20-21, 36.

(167) VAN DER PLANK, J. E.
1939. GRAPE WASTAGE INVESTIGATIONS, 1938. Union So. Africa, Dept. Agr. and Forestry, Ann. Rpt. Low Temp. Research Lab., Capetown, 1937-38: 76-78.

(168) VAN DER PLANK, J. E. and RATTRAY, J. M.
1939. GRAPE WASTAGE INVESTIGATIONS, 1938. Union So. Africa, Dept. Agr. and Forestry, Ann. Rpt. Low Temp. Research Lab., Capetown, 1937-38: 74-76.

(169) WHITEMAN, T. M.
1957. FREEZING POINTS OF FRUITS, VEGETABLES, AND FLORIST STOCKS. U.S. Dept. Agr. Mktg. Res. Rpt. 196, 32 pp.

(170) WILCOX, R. B.
1940. CRANBERRY FRUIT ROTS IN NEW JERSEY. N.J. Agr. Expt. Sta. Cir. 403, 4 pp.

(171) ———
1949. CERTAIN FACTORS AFFECTING FRUIT ROT IN NEW JERSEY CRANBERRY BOGS. Amer. Cranberry Growers' Assoc. Proc. 79: 8-18, 20-24.

(172) WILHELM, A. F.
1944. UNTERSUCHUNGEN ZUR FRAGE EINER CHEMISCHEN BEKÄMPFUNG DER TRAUBENFÄULE (*Botrytis cinerea*). Wein u. Rebe 26(4-6): 29-49; (7-9): 67-73.

(173) WINKLER, A. J., and JACOB, H. E.
1925. THE UTILIZATION OF SULFUR DIOXIDE IN THE MARKETING OF GRAPES. Hilgardia 1: (107)-131, illus.

(174) ———, and JACOB, H. E.
1925. TREATING GRAPES WITH SULFUR DIOXIDE FOR SHIPMENT. Blue Anchor 2(12): 28, 68-72, illus.

(175) WINTER, J. D., ALDERMAN, W. H., and WAITE, W. C.
1935. PICKING, HANDLING, AND REFRIGERATION OF RASPBERRIES AND STRAWBERRIES. Minn. Agr. Expt. Sta. Bul. 318, 39 pp., illus.

(176) ———, LANDON, R. H., and ALDERMAN, W. H.
1939. USE OF CO_2 TO RETARD THE DEVELOPMENT OF DECAY IN STRAWBERRIES AND RASPBERRIES. Amer. Soc. Hort. Sci. Proc. 37: 583-588.

(177) WINTER, J. D., LANDON, R. H., VOGEL, A. C., and ALDERMAN, W. H.
1937. THE CARBON DIOXIDE TREATMENT OF RASPBERRIES AND STRAWBERRIES. Amer. Soc. Hort. Sci. Proc. 35: 188–192.

(178) WRIGHT, R. C., DEMAREE, J. B., and WILCOX, M. S.
1936. SOME EFFECTS OF DIFFERENT STORAGE TEMPERATURES ON THE KEEPING QUALITY OF CRANBERRIES. Amer. Soc. Hort. Sci. Proc. 34: 397–401.

(179) YARWOOD, C. E., SIDKY SOLIMAN, COHEN, MORRIS, and SANTILLI, VINCENT.
1954. TEMPERATURE RELATIONS OF POWDERY MILDEWS. Hilgardia 22: 603–622.

(180) YOUNG, V. H.
1934. OBSERVATIONS ON THE CONTROL OF BLACK ROT OF GRAPES. Phytopathology 24: 841–842.

(181) YOUNG, W. J., and BENEKE, E. S.
1952. TREATMENTS TO PREVENT FRUIT STORAGE ROTS. (Abstract) Phytopathology 42: 24.

U.S. GOVERNMENT PRINTING OFFICE: 1960

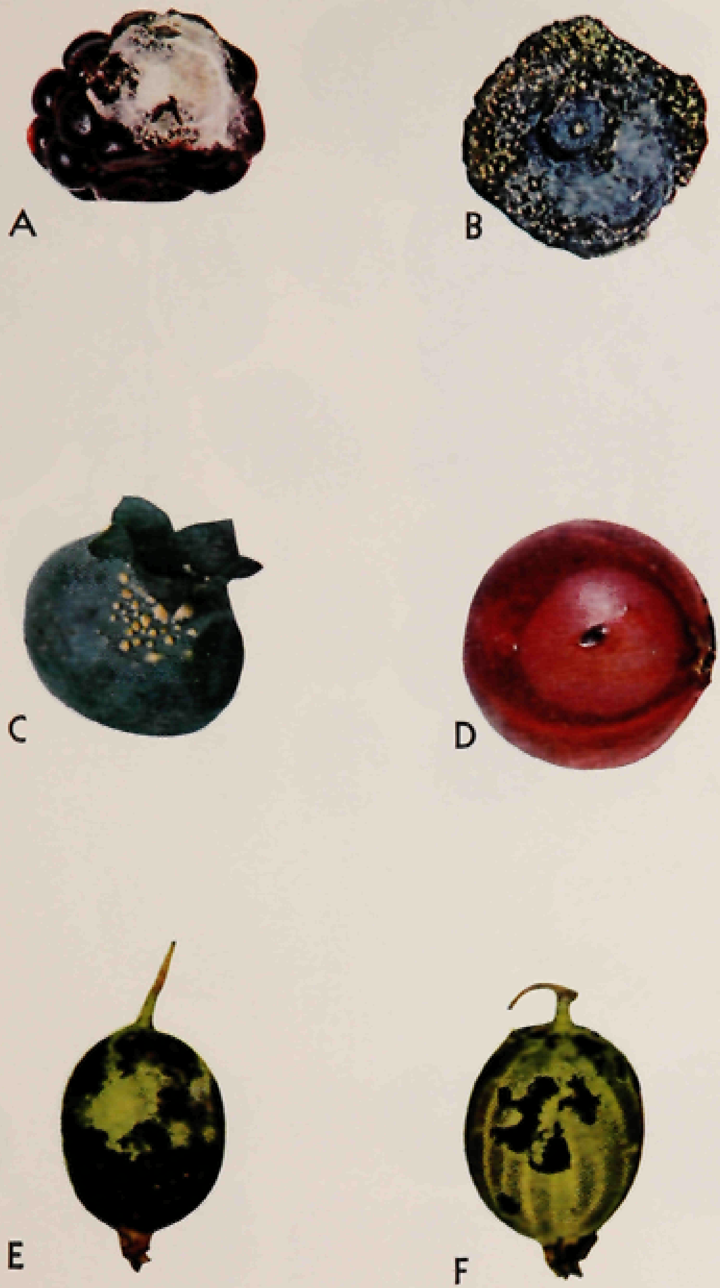

Plate 1.—*A*, Gray mold rot on blackberry. *B*, Gray mold rot on blueberry. *C*, Anthracnose on blueberry. *D*, Gray mold rot on gooseberry. *E*, *F*, Powdery mildew on gooseberry.

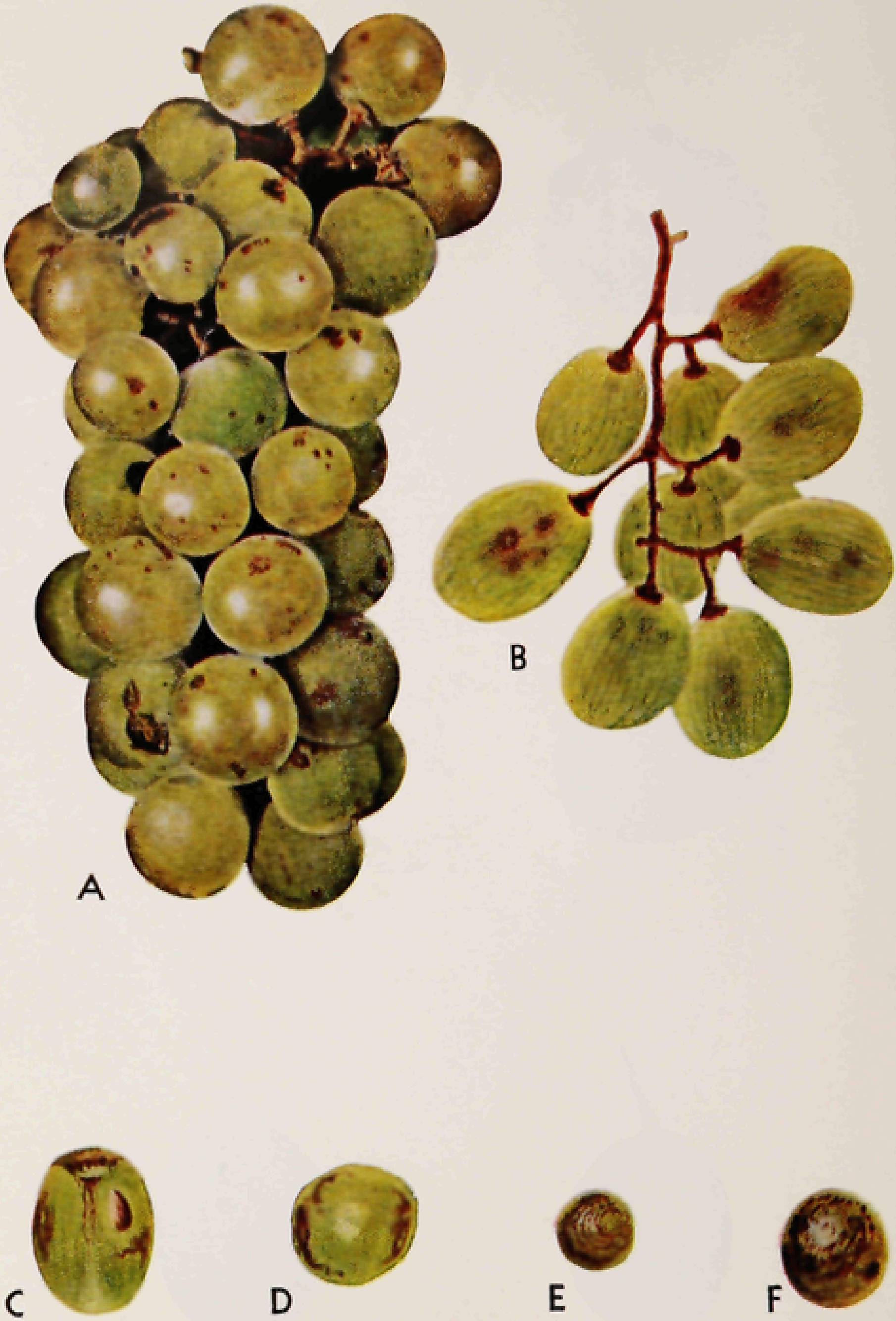

Plate 2.—*A,* Hail injury on Niagara grapes. *B,* Almeria (Ohanez) spot. *C,* Almeria spot on longitudinal section. *D,* Almeria spot in cross section. *E, F,* Ring mildew on Malaga grapes.

A

B

C

Plate 3.—Types of decay found in stored Emperor grapes: *A*, Various stages of gray mold rot. *B*, Stages of Cladosporium rot. *C*, Stages of Alternaria rot.

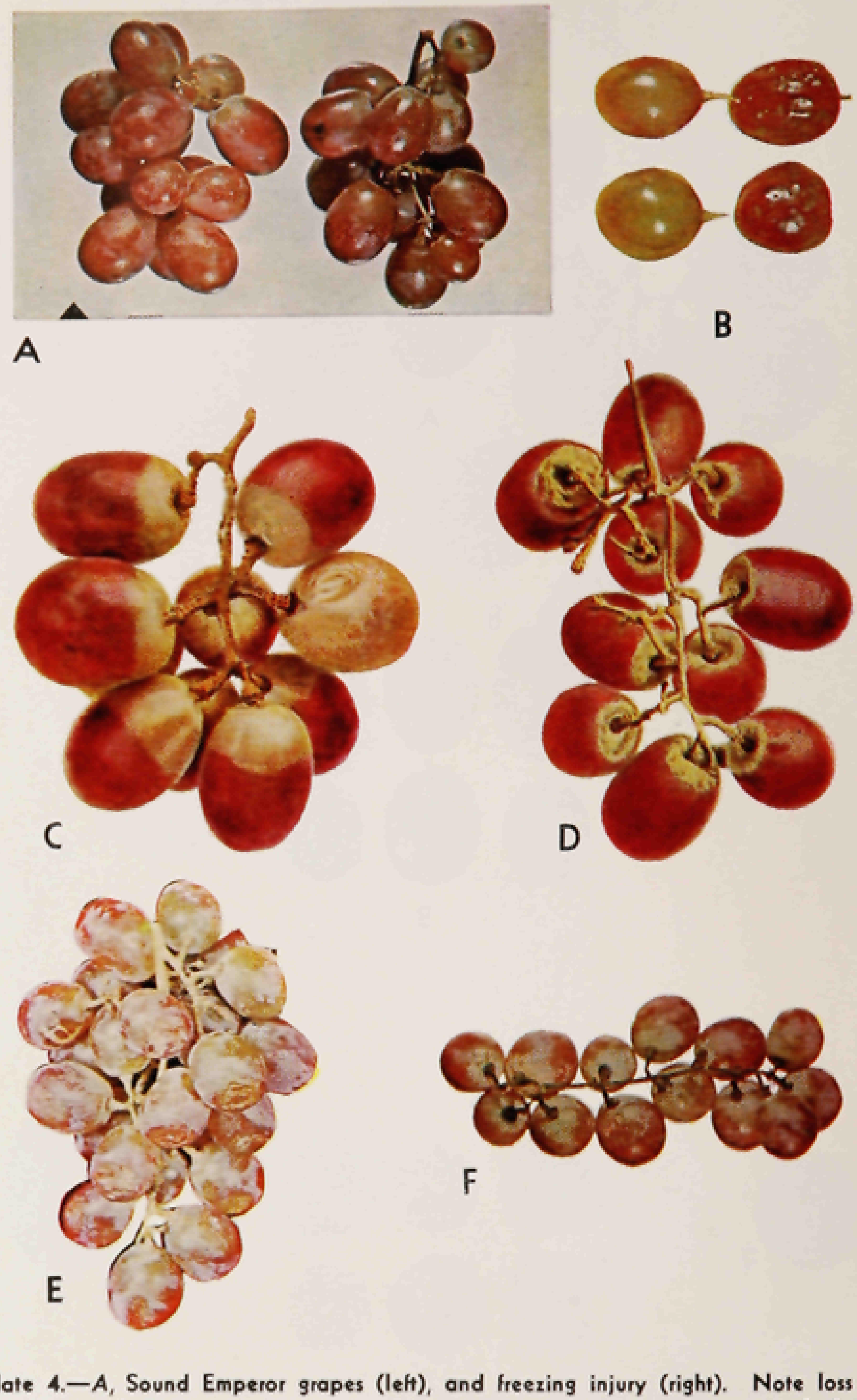

Plate 4.—*A*, Sound Emperor grapes (left), and freezing injury (right). Note loss of luster. *B*, Pitting caused by sulfur dioxide injury to Flame Tokay grapes. *C*, Sulfur dioxide injury to Emperor grapes appearing as a sharply delineated, decolorized area at the stem end. *D*, Later stage sulfur dioxide injury to Emperor grapes appearing as sunken capstems. *E*, Box bruising of Emperor grapes. *F*, Ammonia injury to Emperor grapes; note darkening of capstems.

Plate 5.—*A,* Sun injury on Malaga grapes. *B,* Black measles on Malaga grapes.

Plate 6.—*A,* Gray mold rot on Zinfandel grapes. *B, C,* Slip skin condition of Emperor grapes after about 3 months' storage. *D, E, F, G,* Various stages of black rot on Concord grapes.

Plate 7.—*A,* Blue mold rot on black juice grapes (note moldy stems). *B,* Cladosporium rot on Emperor grapes after holding at warm temperature (note velvety, green growth of mold).

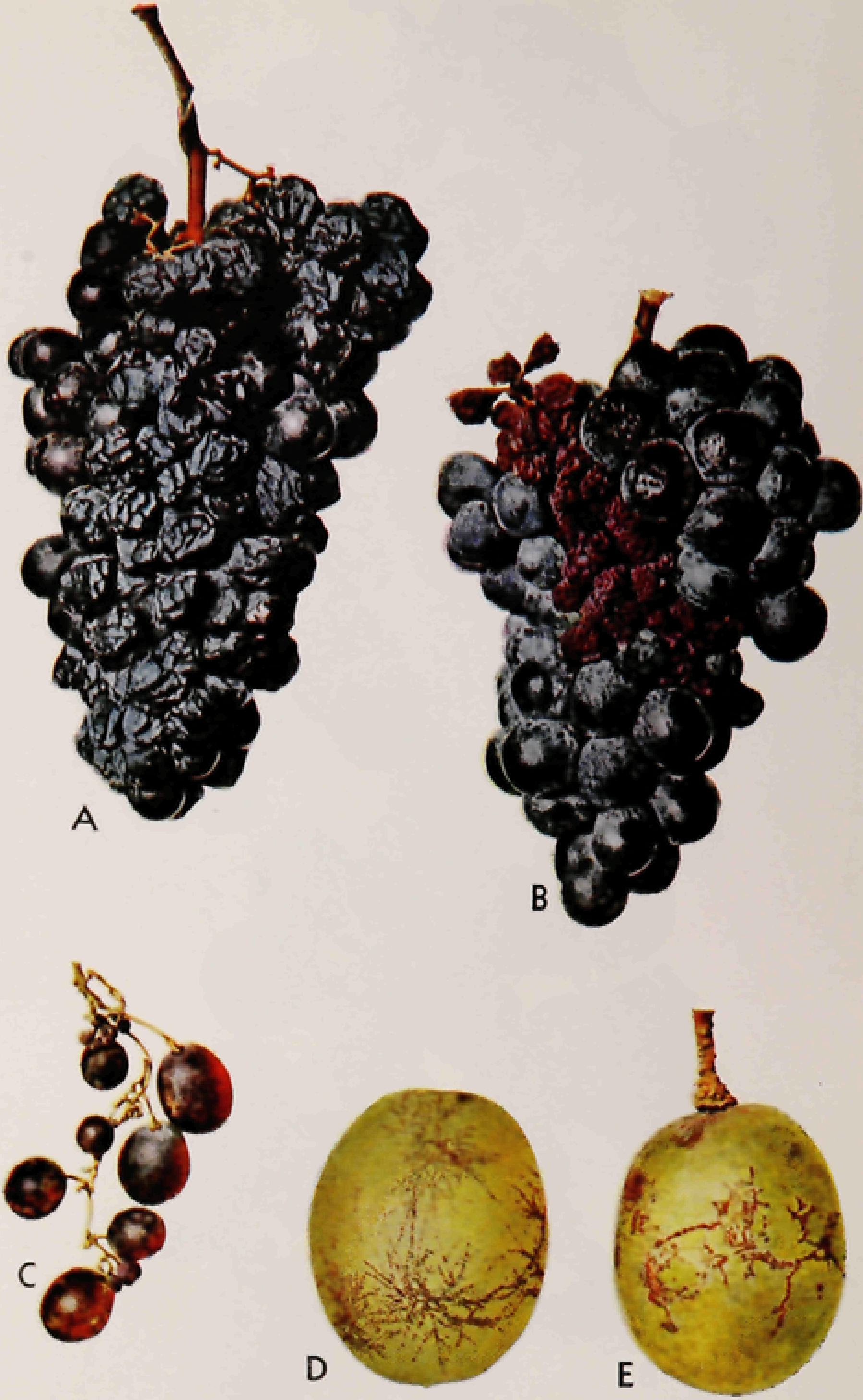

Plate 8.—*A*, Raisining, late stage, on Zinfandel grapes. *B*, Sunburn on Zinfandel grapes. *C*, Shot berry of Emperor grapes. *D*, Powdery mildew on Alexandria (Muscat) grape. *E*, Scarring on Malaga grape.

Plate 9.—*A*, Rhizopus rot on strawberries. *B*, Rhizopus rot on individual strawberry. *C*, Anthracnose on strawberry.

Plate 10.—*A*, Gray mold rot on strawberries, late stage. *B*, Leather rot on Aroma strawberry. *C*, Longitudinal section of Aroma strawberry affected with the same disease. *D*, Rhizoctonia brown rot on Missionary strawberry (color of rot partly masked by adhering soil). *E*, Tan brown rot on Missionary strawberry. *F*, Gray mold rot on green strawberry a short time after infection. *G*, Gray mold, early stage, on ripe strawberry. (*B, C, D, E,* and *F,* from Dodge and Stevens (47).)